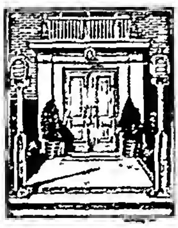
COMPTON'S PICTURED ENCYCLOPEDIA AND FACT-INDEX

Interesting · Accurate · Up-to-date

TO INSPIRE AMBITION,
TO STIMULATE THE IMAGINATION, TO PROVIDE THE
INQUIRING MIND WITH ACCURATE
INFORMATION TOLD IN AN INTERESTING
STYLE, AND THUS LEAD INTO
BROADER FIELDS OF KNOWLEDGE,
SUCH IS THE PURPOSE OF
THIS WORK



Volume 12

1956 Edition

PUBLISHED BY
F. E. COMPTON & COMPANY · CHICAGO

1956 EDITION

COMPTON'S PICTURED ENCYCLOPEDIA

LIBRARY OF CONGRESS CATALOG CARD NUMBER: 55-9384

Here and There in This Volume

AT ODD TIMES when you are just looking for "something interesting to read," without any special plan in mind, this list will help you. With this as a guide, you may visit faraway countries, watch people at their work and play, meet famous persons of ancient and modern times, review history's most brilliant incidents, explore the marvels of nature and science, play games—in short, find whatever suits your fancy of the moment. This list is not intended to serve as a table of contents, an index, or a study guide. For these purposes consult the Fact-Index and the Reference-Outlines.

Pictures You Will Enjoy

For the Reading Hour

Parent and Child; School and Home

High Lights in History's Pageant

Some Famous Men and Women

HERE AND THERE IN THIS VOLUME

Travel Views of Lands Across the Seas

Tours Through North and South America

In the Plant and Animal World

Marvels of Science and Invention

The World at Work

Guideposts to Literature, Art, and Music

Exploring a World of Facts

Interest-Questions Answered in This Volume

Does a plant get most of its food through its roots or through its leaves? 227.
What animal has been responsible for the death of more humans than all the wars of history? 76.
What quadruped has bird friends that eat tiny ticks from the folds of its skin? 134 picture.
From what bird's egg do we take the name of a lovely color? 164.
What mischievous animals are called "little brothers of the bear"? 20 pictures.
How is the Red Cross financed? 87*a*.
How does a fish breathe? 117 picture.
What bird makes its nest on a raft? 57.
What rock will float on water? 167.
What are the peculiarities of rodents' teeth? 176.
How far can a rattlesnake strike? 78.
How much rainfall is needed for ordinary farming? 70.
Where in North America do millions of people preserve the culture of old France? 4.
What "eye" can pierce fog, storm, or black night as far as the horizon and show an observer ships, planes, and coast lines? 25.
What country doubled in size and population after World War I? 254.
Which race overran the earth between the 15th and 20th centuries? 23.
What is the most important natural force in shaping land surfaces? 155.
What is the only walled city in North America? 10.
Why is rainfall dependent on winds? 70–1.
What great South American harbor is big enough for all the navies of the world ? 154.
Which state in the United States is the most densely populated? 135.
What empire girdled the Mediterranean? 182 map.
Why are the "Romance" languages so called? 180.
What is the origin of the Red Cross Societies? 87.
What suggested the graceful loop design used in Paisley shawls? 156 picture.
Explain briefly why roads may be called the measure of progress of a community? 158-158*a*.
How does food make your mouth "water"? 89.
Why do visitors to Rome throw coins into the Fountain of Trevi? 195.
Why can a hog safely attack a rattlesnake? 78.
When did a whole nation go on a strike? 183.
What president rode a horse 90 miles within 24 hours to set an example of fitness to the army? 220–22.
Summarize the differences in social and political outlook between England and America just before the Revolution. 123.
Where did Congress get the funds to fight the Revolutionary War? 126.
What great artist was also a famous diplomat? 246.
How did the American custom of driving on the right originate? 160.
In what nation were the peasants held in serfdom until 1861? 287.
Why were bloody English wars given the poetical name of "Wars of the Roses"? 232.
How did a churchman make France the foremost power in Europe? 152.
What are the Rhodes Scholarships? 144.
Do you believe that Robespierre should be blamed for the Reign of Terror during the French Revolution? 163.
What Elizabethan courtier paved the way for the settlement of America? 73.
What king of England made but two brief visits to England during his reign? 149.
Where was "the Seat Perilous"? 236.
What bird's figure was displayed on the flag of the Northmen? 79.
What do you consider the chief inspiration to be obtained from Theodore Roosevelt's life? 219.
Whose horn sounded so sweet and penetrating that the ground shook and the birds fell from the trees? 178.
What Roman heroes were said to have been nursed by a wolf? 198.
What outlaw robbed the rich to aid the poor? 164.
Is it possible for a person to suffocate himself by holding his breath? 90.
What famous picture was sketched on a wine cask cover? 75 picture.
What president was married to the niece of another president? 199.
Why are two Oriental rugs rarely alike? 248.
What great artist used himself as his model for more than 50 paintings? 103.
What French author made caustic fun of people's vices and foolishness in fairy tales? 19.
How far will a radio wave go in one second? 33.
How can ships be controlled from a distance without pilot or crew? 40.
What religion has the most followers? 101.
Why is Goodyear's discovery of vulcanization considered so important? 242.
Where is the largest church in the world? 196.
How is quack grass helpful? 1 picture.
How does a train operate its own warning signals without human help? 66, picture 64.
What inspired the revival of art and literature during the Renaissance? 103.
What grain furnishes the principal food for one half of all mankind? 147.
What is a collective farm? 264.
What grows above the timber line in the Rockies? 174.
How can you tell from the number of a federal highway in what direction it runs? 158*e*.
What is the cost of one gram of pure radium? 57.
What artist painted more than 300 pictures of the Madonna? 74.

KEY TO PRONUNCIATION

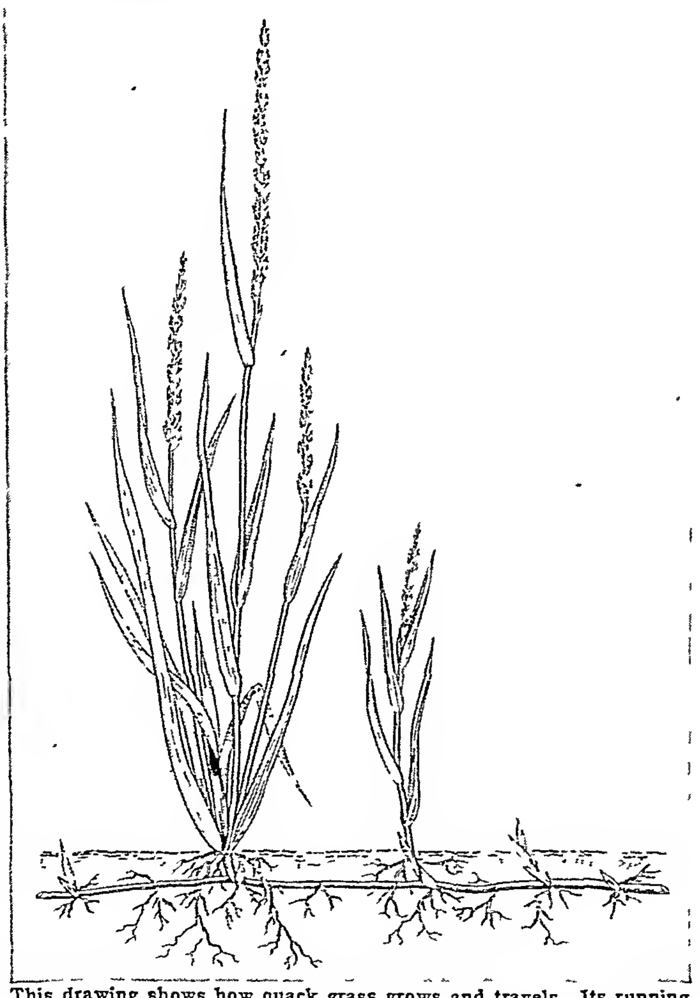
Pronunciations have been indicated in the body of this work only for words which present special difficulties. For the pronunciation of other words, consult the Fact-Index. Marked letters are sounded as in the following words: cāpe, ăt, fär, fȧst, whạt, fa̤ll; mē, yĕt, fẽrn, thêre; īce, bĭt; rōw, wȯn, fôr, nŏt, do̤; cūre, bŭt, ru̥de, fu̥ll, bûrn; *out*; ü=French *u*, German *ü*; ġem, ḡo; *th*in, *th*en; ṅ=French nasal (Jeaṅ); *zh*= French *j* (*z* in azure); ᴋ=German guttural *ch*.

Q

QUACK GRASS. Although this perennial of the barley tribe has some value to grazing sheep, quack grass is generally considered a troublesome weed. Above the ground its flat leaves grow to a height of from one to four feet, resembling many another grass. But running horizontally beneath the surface of the earth are yellowish-green rootstocks which spread to new areas constantly. When these rootstocks are cut by a farm implement, each segment sends forth a new plant. This makes it very difficult to eradicate once it has gained a foothold. To pull up the entire root system of each patch of the grass is the only sure way to get rid of this plant pest.

A native of Europe, quack grass is now found in eastern Canada and in the United States as far south as Iowa and Virginia. Dense clumps of this grass are favorite shelters for small ground-nesting birds. Quack grass is also called couch grass, quick grass, quitch grass, devil grass, and witch grass. Scientific name, *Agropyron repens.*

HOW A PERSISTENT WEED SPREADS



This drawing shows how quack grass grows and travels. Its running rootstock sprouts sharp blades that cut their way up through obstacles and develop at last into dense clusters to smother rival plants. Those grasping roots, however, often help to prevent soil erosion.

QUAIL. One of the few birds that are benefited by the coming of the farmer is the quail. It spends the summer and fall on the farm, scratching for weed seeds and the grains left after harvest; and retreats to the woods only in winter. The bird's delicious flesh and its swift flight make it a great favorite with sportsmen. Many states have established preserves where the birds may multiply in complete safety. These states will stock a farmer's land with a colony of quail on condition that he will allow no hunting for an agreed period. In other places the hunting season is usually restricted to a few weeks in the fall to prevent the extermination of the birds.

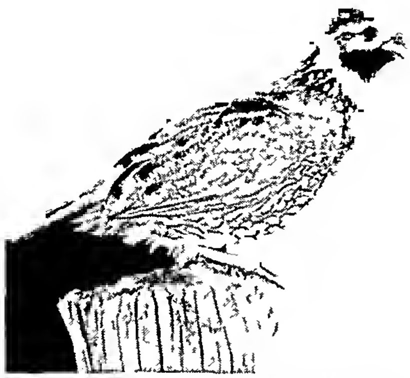
There are several species of American quail, varying in length from 9½ to 11 inches. The most familiar is the bird known in the North as the bobwhite and in the South as the partridge. It earned its name with its questioning call—*bob, bobwhite?* It breeds eastward from the Rockies and from Canada to northern Texas and Florida. California and mountain quail are found in the humid districts of the Pacific coast. In the arid Southwest are Mearns's, Gambel's, scaled, and valley quail. Two species of Old World partridges, closely related to the American quail, have been successfully introduced in the Northwest and Middle West. These are the blue-gray European, or Hungarian, partridge from central Europe and the chukar partridge from India.

The plumage of the bobwhites—a mixture of mottled brown and buff-gray and white—makes them almost invisible when they lie quietly in fields or woods. (For picture in color, *see* Birds.). They squat motionless until one is on the point of stepping on them. Then they take wing explosively.

They nest in open brushy fields where they can find good cover. The nest holds 12 to 18 white eggs. The chicks leave the nest immediately after hatching, but the family keeps together in a covey until the following spring. When scattered they are brought together by the call of the parents. At night the birds sleep on the ground in a circle, bodies packed closely together and heads facing outward, so that they can watch for enemies and scatter instantly at an alarm. They do not migrate but take to the deep woods in the winter. The valley quail is the state bird of California. The bobwhite is the unofficial state bird of Rhode Island.

Quail and partridges belong to the family *Perdicidae*. The true partridges, native to Europe and Asia, belong to the subfamily *Perdicinae;* the American quail belongs to the subfamily *Odontophorinae.* The scientific name of the bobwhite is *Colinus virginianus;* scaled quail, *Callipepla squamata;* California and valley quail, *Lophortyx californica;* Gambel's quail, *Lophortyx gambeli;* mountain quail, *Oreortyx picta;* and Mearns's quail, *Cyrtonyx montezumae;* Hungarian, or European, partridge, *Perdix perdix;* chukar partridge, *Alectoris graeca.*

THE PERKY BOBWHITE



This bobwhite, perched on a fence post, was caught by the photographer's flashlight.

QUAKERS. In 1652, George Fox, standing on high Pendle Hill in England, had a vision (*see* Fox, George). This was the beginning of the Religious Society of Friends Its members are called Quakers. A magistrate first used the name when Fox was on trial for his beliefs in Derby in 1650 because his followers trembled during religious excitement. Fox bade the judge "to tremble at the word of the Lord."

The Society of Friends grew out of the Puritan movement in England. George Fox believed that the formal worship and creed of the Church of England robbed Christianity of its true spiritual quality. He taught that an individual can worship God by direct communication without a minister as intermediary.

As a wandering preacher Fox won thousands of followers. They refused to attend services of the Church of England or to contribute tithes for its support. They were pacifists because they felt that war causes spiritual damage through hatred. They refused to take oaths because an oath recognized a double standard of truth. They were frugal and plain in dress and speech. The authorities persecuted them with fines, imprisonment, and confiscation of property. Nevertheless the sect flourished, and in 1689 the Toleration Act ended the persecution.

The climax of the Quakers' efforts to establish themselves in America came in 1681 with a large grant to the Quaker William Penn (*see* Penn). The Hicksites separated from the Orthodox Quakers in 1827, but their differences now are unimportant.

The Quakers of today reflect the teachings of Fox. They do not sanction taking part in war, but individuals follow their own convictions. Most Quakers are conscientious objectors, but some participate in war.

The Friends have no ritual and do not observe baptism or the Lord's Supper. They have no ordained ministers but appoint elders and overseers to serve each meeting. The church records as ministers men and women who have received a "gift." The Meeting for Worship is held "on the basis of silence." Members speak in prayer or testimony as the Inner Light moves them. After an hour the meeting ends with members shaking hands. The Society accepts more current Protestant practices in worship, especially in the Middle and Far West. Congregations hold a Meeting for Business monthly. Groups in a district have Quarterly Meetings; those of a region, Yearly Meetings. All can attend, but usually congregations send delegates.

Quakers are active in welfare work and in social reform. The American Friends Service Committee, founded during World War I, organizes relief and service projects all over the world. (*See also* **Religion** table in FACT-INDEX.)

QUARRYING. The great structures of ancient Egypt and Greece and the roads built by the Romans prove that men have been skilled quarry workers for thousands of years. In those ancient times it was backbreaking labor with hand tools, and often no one but slaves could be forced to work in the quarries. With modern machinery and methods quarrying is easier, but many operations still require men to work with picks, sledge hammers, and pneumatic hand drills.

The building stones taken from quarries may be classified as limestones, sandstones, granites, marbles, and slates. Oolitic limestone has a fish-egg texture. Commercial granite includes a group of metamorphic rocks, such as schist and gneiss, and the igneous rock called granite. Limestone and sandstone were formed as bodies of water deposited sediment through

AN OHIO SANDSTONE QUARRY

This sandstone quarry near South Amherst, Ohio, has already yielded huge blocks of stone from its ledges. Channeling machines do the cutting. Cranes lift the blocks onto cars which carry them to the stone mill.

geologic epochs. These are the most easily quarried because they usually have definite layers of stratification. Granite and other igneous rock also have lines of easy cleavage although they are not stratified. (*See also* Rock; Geology.)

Limestone, marble, and granite are still much used for buildings and monuments (*see* Limestone; Marble; Granite; Slate). Cheaper substitutes, such as tile and special glasses, have been developed for building purposes. Most of the output of United States quarries is crushed stone, used in concrete or for road construction (*see* Concrete). Much limestone goes into making lime and portland cement (*see* Cement).

Freeing Rock from the Quarry

After the overburden is stripped from a quarry, the next step is *channeling*. This frees blocks of stone by cutting grooves. The channeling machine looks like a small locomotive that travels back and forth on a track pinned to the rock. It strikes on one or both sides of the track with sets of chisels placed at different angles. Air pressure vibrates the chisels up and down, cutting a channel about an inch and a half wide and generally ten feet deep. The ordinary channeling machine makes only vertical cuts. A horizontal channeler called a *gadder* is used for undercutting. Other equipment for severing stone include air broaching machines and wire saws.

The key block on the quarry floor may be removed by a derrick pulling on it while one side is wedged or pried. Separation of blocks of stone is usually continued by the less expensive *plug-and-feather* method. Quarrymen drill a row of holes, in general not more than ten inches deep, along the line of the expected split. In each hole they place two *feathers*—flat pieces of steel rounded on one side to fit the curve of the hole. A narrow tapered wedge called a *plug* is driven between the feathers. Then in succession they strike all the plugs. The splitting force of the wedges is enough to break the rock away from its ledge. Sometimes compressed air is blown into the holes to further the action of a crack already started.

Explosives were once used extensively for detaching large blocks of stone. Quarry workers would drill a row of vertical holes, fill them with a slow-burning explosive, such as gunpowder, and then explode the whole row simultaneously. Since explosives shatter the building stone, using them is no longer good quarry practice. High explosives, such as dynamite, are used when the rock is to be broken into fragments.

The rectangular masses of stone may weigh tons. Great cranes swing these onto cars which haul them to the stone mill. There the stone is cut by saws of various types—swinging gang saws with chisellike teeth, circular saws, or smooth, flat blades fed with flint sand and water. Finishing is done by hand carving or by planing machines or lathes. Some stones are polished. For crushed stone, pieces—some as large as pianos—are broken in giant gyratory crushers.

QUARTZ. The two commonest chemical elements in the earth's crust, oxygen and silicon, combine to form quartz. This is the most abundant of all minerals except feldspar (*see* Feldspar). Most sands are broken-down and waterworn fragments of quartz. Sandstone and quartzite are the same materials built up into rock again. Quartz is also an important constituent of granite. (*See* Granite; Sand.)

Quartz is hard enough to scratch glass, but not as hard as diamond, sapphire, or topaz. It occurs in masses of very fine crystals, such as flint, jasper, and agate. It also is found as large crystals often beautifully colored by impurities, including many of the semiprecious stones (*see* Crystals; Silicon). Quartz, quartz sand, and sandstone are used for making sandpaper and other abrasives, such as grindstones, polishing powders, and soaps; for building materials; for heat-resisting materials (refractories); and for the bearings of precision instruments.

Scarce and Valuable Quartz Crystals

Clear natural quartz, called *rock crystal* or *quartz crystal*, is used in radio transmitters to maintain a constant wave frequency (*see* Radio). This type of quartz is somewhat rare. It is found in abundant quantities only in the Brazilian states of Bahia and Minas Gerais. The need for electronics equipment during World War II made quartz crystals a critical item. The United States imported millions of pounds by airplane to meet the increased demand.

To prevent future shortages in the quartz crystal supply, scientists have developed a method of "growing" the mineral in laboratories or industrial plants. A "seed," or small piece, of natural quartz crystal is held in a dilute alkaline solution, with a quantity of silica to act as "feeder" material. Under heat and pressure, the silica undergoes change and slowly deposits on the seeds. This action gradually builds up a piece of almost flawless crystal about one pound in weight and indistinguishable from natural quartz.

Fused Quartz for Many Uses

For purposes where the crystalline structure of natural quartz is not essential, noncrystalline fused quartz is used. This is made by melting pieces of natural quartz in an electric furnace.

Fused quartz shows virtually no expansion or contraction under changes in temperature, making it valuable for mirrors and lenses that must remain accurate in widely varying conditions, such as those used in telescopes. It is also used for condensing lenses in motion-picture machines, where the heat of the high-intensity arc light often breaks glass. It is one of the best electric insulators known.

As clear as air itself, fused quartz transmits heat rays, light, and ultraviolet rays better than any form of glass. Mercury-vapor lamps with tubes of fused quartz are powerful sources of the ultraviolet radiation used in medicine. Rays, visible or invisible, entering one end of a fused quartz rod will for the most part follow the rod around corkscrew twists and right-angle turns, instead of coming out through the sides. Thus light can actually be "piped around corners." Fused quartz resists hot acids and is widely used for test tubes and other containers that hold chemicals in reaction.

Where OLD FRANCE *Lives on in* MODERN CANADA

The strip farms of Quebec slope down from the forested hills to the banks of the St. Lawrence River. Neat stone fences mark their boundaries. The "habitants," or French farmers, live in villages clustered about the white church on the river front.

QUEBEC (*kwē-bĕk'*), CANADA. Two different civilizations seem to live side by side in Quebec. The highly industrialized modern world is evident in Montreal, the second largest city in Canada; in the St. Maurice Valley, with its great hydroelectric stations, its chemical plants, its pulp and paper and textile mills; in Noranda, with its copper smelter; and Arvida, with the world's largest aluminum reduction plants. Even in the forested wilderness of the Far North an exciting future of settlement and development is within reach with the discovery of a vast iron range and other minerals vital to the modern world.

Extent.—North to south, greatest distance, 1,225 miles; east to west, 982 miles. Area, 594,860 square miles (71,000 water). Population (1951 census), 4,055,681.

Natural Features.—Rolling country, Notre Dame Mountains south of St. Lawrence (highest point, Jacques Cartier Peak, 4,300 feet), St. Lawrence Valley lowlands, forested Laurentian Plateau (1,000 to 2,000 feet). Lakes: St John, Abitibi, Mistassini, Albanel, Minto, Payne, Clearwater, Lower Seal, Apiskigamish, Kaniapiskau, Memphremagog. Rivers: St. Lawrence and tributaries Saguenay, St. Maurice, Ottawa, Richelieu, St. Francis, Chaudière, entering Hudson Bay or Strait, Nottaway, Rupert, Great Whale, Leaf.

Products.—Pulp and paper, nonferrous smelted and refined products, meat, petroleum products, cotton yarn and cloth, factory clothing, railway rolling stock, tobacco, hay and clover, oats, potatoes, mixed grains; milk, hogs, cattle, poultry, eggs, asbestos, gold, copper, zinc, cement, lumber, fur; cod, lobster, salmon

Cities.—Montreal (1,021,520), Quebec (capital, 164 016), Verdun (77,391), Sherbrooke (50,543), Trois-Rivières (Three Rivers) (46,074), Hull (43,483), Outremont (30,057), Lachine (27,773).

In sharp contrast is rural Quebec, where the French-Canadian *habitant*, or farmer, clings to a culture that stems from 17th-century France. About five sixths of Quebec's people are descendants of the original French founders of the province 300 years ago. They have kept their language, their Roman Catholic faith, their schools, and their civil law.

In some areas, especially on the Island of Orleans in the St. Lawrence River and on the Gaspé Peninsula they enjoy the simple life of the early settlers. One sees wayside shrines, outdoor bake ovens of clay roofed over with peaked wooden slats, plodding oxen, and along the river bank, tiny villages, each with a white church in its center. The parish priest is still the most respected and influential member of the community. Large families of 12 or more children are not uncommon. The Quebec French have increased from about 55,000 in 1754 to about 3 million in 1951. Many people of French descent have settled in other parts of the nation, where they now number about one third of the population. Many too have settled in Maine and other New England states.

The ancient walled city of Quebec, the capital of the province, with its many relics of a colorful and romantic past, is one of the most interesting cities in North America (*see* Quebec, City of).

Largest Province in Canada

Quebec's area of 594,860 square miles is larger than Texas, California, and Montana combined, and nearly seven times larger than Great Britain The province extends for 1,225 miles from Hudson Strait and Ungava Bay on the north to the Ottawa River and the United States border on the south. From Ontario, James Bay, and Hudson Bay on the west to Labrador on the east is nearly a thousand miles.

Nine tenths of the province lies within the Laurentian Plateau, also known as the Canadian, or Precambrian Shield (*see* Laurentian Plateau). This is a vast, tilted tableland, much of it covered with forests, lakes, and swift-running streams. The level

plateau drops down to the St. Lawrence River valley in the picturesque Laurentian Mountains. These are actually the eroded face of the plateau. In the Laurentians are many tourist resorts. Hunting and fishing and winter sports, especially skiing, attract thousands of visitors throughout the year. Northwest of Montreal, one of the most popular resorts is the Mont Tremblant (Trembling Mountain) Provincial Park (770,500 acres). The Laurentides Provincial Park (2,373,120 acres), north of Quebec City, and Mont Orford Provincial Park (9,970 acres), southeast of Montreal, are also popular. La Vérendrye Provincial Park (1,732,000 acres), in the western part of the province, lies along the road from Montreal northwest to Lake Abitibi.

Northeast of Quebec City the Saguenay River flows into the St. Lawrence. Its magnificent scenery makes it one of Canada's most popular tourist regions. The river valley is a trough caused by a slip of the earth along a crack, and deepened by glaciers. Near the mouth of the river two cliffs, known as Cape Trinity and Cape Eternity, soar 1,600 and 1,800 feet respectively above the river. At this point its bed is 800 feet deep. The village of Tadoussac, at the mouth of the Saguenay, claims to be the oldest settlement in Canada. A fur-trading post was built here in 1599.

The St. Lawrence River valley is a fertile lowland plain of great beauty and charm. Its clay soils are deep and rich, its climate temperate. Here are most of Quebec's agriculture and industry and its oldest and largest cities. It is the most densely populated region in Canada. Three-fourths of Quebec's people live within 25 miles of the river. Along the shores of the river lie the characteristic French-Canadian strip farms. They are frequently not more than 30 rods (495 feet) in width, and stretch back a mile or more to the mountains. The farmhouses cluster together in tiny villages on the river bank. These odd farms were laid out in the 17th century in order to give each one a frontage on the river, the only means of communication in a wild and thinly settled country.

Southern Quebec

On the south side of the St. Lawrence River, the Appalachian Mountain system comes to an end in a broad highland broken by parallel ridges known as the Notre Dame Mountains. Southern Quebec is divided into three sections—the Eastern Townships, the South Shore, and the Gaspé Peninsula.

The Eastern Townships lie east of Montreal, between the river and the border states of New York, Vermont, New Hampshire, and Maine. Low wooded ranges of the Appalachians cross the area from west to east. Cutting diagonally across these ridges is a belt of igneous rock which holds the world's largest deposits of asbestos. Sherbrooke is the largest city and marketing center. This is a land of prosperous stock and dairy farms, apple orchards, and fields of hay, oats, and sugar beets. The Chaudière River valley is Canada's leading source of maple sugar and syrup.

The South Shore extends from Lévis, opposite Quebec City, to Rimouski. It is a fertile farming area between the St. Lawrence and the Notre Dame Mountains. The population is almost entirely French. Rivière du Loup is the largest city.

The Gaspé Peninsula

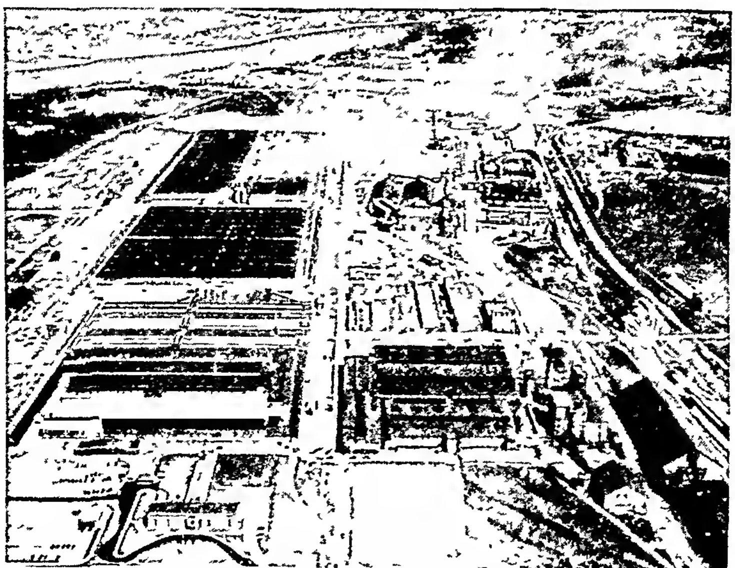
The Gaspé Peninsula is the tongue of land which extends eastward into the Gulf of St. Lawrence, between the St. Lawrence River on the north and Chaleur Bay on the south. It is about 170 miles long and 60 to 80 miles wide. The Notre Dame Mountains form the backbone of the peninsula. Along the St. Lawrence, where they are known as the Shickshocks, they rise abruptly from the water's edge to heights of more than 3,000 feet. Jacques Cartier Peak is 4,300 feet high. Fishing and lumbering are the chief occupations of the French villages on the river bank and Gulf. Along Chaleur Bay, farming is practiced.

The interior is still a wilderness of mountain and forest. Gaspesian Provincial Park (320,000 acres) is remarkable for its plant life, which dates from times prior to the glacial age. Herds of caribou are protected within the park. Bonaventure Island, off the tip of the peninsula beyond the village of Percé, is a bird sanctuary, notable for its colonies of nesting gannets and other sea birds. The Perron Boulevard completely rims the peninsula, making it accessible to tourists and artists who delight in the charming villages and the spectacular scenery of sea and mountain.

Water Power and Industries

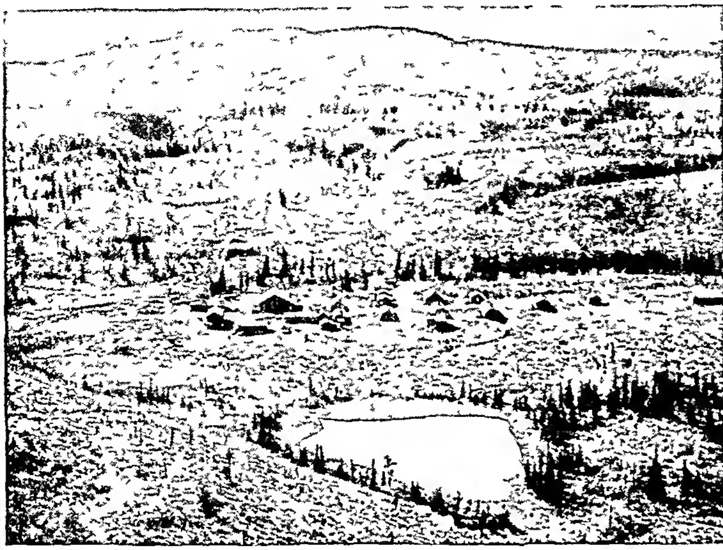
The tilted plateau, with its countless lakes and streams and ample rainfall enjoys almost unlimited water power. Quebec ranks first among the provinces in water power. Developed power totals about

ONE OF CANADA'S GIANT INDUSTRIES



The aluminum reduction plant at Arvida, in the Saguenay River district, is the largest in the world. Hydroelectric power is provided at the Shipshaw dams. The bauxite ore is shipped from British Guiana.

MINERAL PROSPECTING IN THE FAR NORTH



At the left is shown the Burnt Creek camp, established to survey the great iron range on the Quebec-Labrador border. At the right, a helicopter, chartered by the Dominion Topographical Survey, picks up surveyors at a remote triangulation station.

7 million horsepower, and potential power is estimated at about 20 million horsepower.

The St. Maurice Valley, known locally as La Mauricie, is one of the most highly industrialized sections of Canada as the direct result of the development of low-cost hydroelectric power. The St. Maurice River is 350 miles long, emptying into the St. Lawrence at the city of Trois-Rivières (Three Rivers). From the Gouin Reservoir at its headwaters, it drops 1,315 feet in 17 falls and rapids.

Six hydroelectric plants generate a total of nearly 1,300,000 horsepower. This power operates the industries of the valley. Trois-Rivières is the world's greatest producer of newsprint. Shawinigan Falls, 21 miles upstream, where the river plunges 145 feet, has huge chemical and aluminum manufacturing plants, pulp and paper mills, cotton, stainless steel, carborundum, carbide, and cellophane factories. Grand'Mère and La Tuque, still farther upstream, are also important manufacturing centers adjacent to water power.

The Saguenay River-Lake St. John region, northeast of Quebec City, is another industrial section dependent on hydroelectric power. The Saguenay is the outlet of Lake St. John. From the lake to the St. Lawrence River, into which the Saguenay flows, the difference in elevation is 300 feet. The great Shipshaw dams and power plants, near the headwaters of the river, completed in 1943, generate about 1,200,000 horsepower. This operates the aluminum reduction plants at Arvida, where bauxite ore, shipped from British Guiana, is converted into aluminum ingots. Above Shipshaw, at the outlet of the lake, are the Île Maligne Falls. Here power is generated for the paper mills of Riverbend and St. Joseph d'Alma. Chicoutimi, Jonquière, and Kenogami are manufacturing towns south of the lake. Dolbeau, at the north end, is another papermill town.

A GASPÉ FISHERMAN

Seated on the wooden pilings of a pier, placidly smoking his pipe, a Gaspé fisherman mends his nets. Fishing is the chief occupation of the French-speaking Gaspesians.

A Climate of Extremes

Because of its great size, Quebec lies in several climatic zones. The mildest section is the St. Lawrence lowland near Montreal. Temperatures average 69.8° in July, 13.8° in January, with extremes of 97° to 29° below zero. The annual precipitation totals 40.8 inches, evenly distributed through the year. About 112 inches of snow falls in a winter.

Lennoxville, near Sherbrooke, in the Eastern Townships, is higher in elevation and has a more severe climate. The July average temperature is 66.2°, the January average 12.8°, and extremes are 99° to –48°. Total precipitation averages 39.56 inches.

At Arvida, on the Laurentian Plateau, the July average is 65° and the January average only 3.6°. Extremes range from 95° to –42°. The precipitation totals 38.93 inches. In the Far North, at Ft. McKenzie, winters average –12.5° and may reach –60°, while the July average is only 54.2°. The annual total of rainfall is 22.04 inches.

The average dates of killing frost are: Montreal, October 17 to April 28; Lennoxville, September 9 to May 28; Arvida, September 19 to May 19; and Ft. McKenzie July 26 to July 8.

A Varied Agriculture

Agricultural production is confined primarily to both shores of the St. Lawrence River and the Eastern Townships. Fertile soil, generous rainfall.

moderate temperatures, and a six months' growing season favor a variety of crops. Milk, butter, Cheddar cheese, and other dairy products are the chief source of farm income. The raising of hogs, cattle, and poultry for meat and eggs is another large branch of farming. Field crops include hay and clover, oats, potatoes, mixed grains, fodder corn, field roots, and barley. Truck farming, fruit growing, and production of maple sugar and syrup are important.

East of Lake Abitibi is Quebec's newest agricultural area. The fertile soils of a so-called "clay pocket" make farming possible. With the building of highways and railroads, the region has been rapidly settled. The commercial center is the town of Amos. Another clay pocket occurs on the shores of Lake St. John, some 400 miles to the east. The south shores, around the town of Hébertville, have the deepest and best-drained soils. These regions are favorable to dairying and to such crops as hay and potatoes, which thrive in a short growing season.

Forests and Fisheries

Quebec's forest lands are enormous. North of the 52d parallel of latitude, in an area still inaccessible and completely undeveloped, lie an estimated 310,000 square miles of forest. These are Crown lands—that is, ownership of the land is vested in the government. South of the 52d parallel, forests total about 265,000 square miles, including 238,000 square miles of Crown forests.

The government controls logging operations by issuing licenses to private operators. Sawmills and lumber mills are scattered throughout the southern part of the province. They are especially numerous on the Ottawa River and its northern tributaries. The logs are floated down the rivers to the mills. Many of the camps in the forests can be reached only by canoe in the summer and by hydroplane and diesel sleigh trains in the winter.

Fishing is the leading industry of the North Shore of the St. Lawrence east of the Saguenay River, and of the Gaspé Peninsula. Gaspé salmon are considered the finest in the world. Between 50 and 60 million pounds of cod are taken every year in the waters beyond the peninsula. Other commercial fish are herring, mackerel, lobster, and smelt.

Great Mineral Wealth

Quebec is second to Ontario in the value of its mineral production. In the Laurentian Plateau is a vast store of mineral treasure. The greatest part of it is still unexplored, but exciting new discoveries are being made. A great iron ore deposit on the Labrador border promises to overshadow the Mesabi Range of Minnesota in size and in the quality of the ore. The ore-bearing formation is believed to be 225 miles long and about 60 miles wide. Transportation into the area was opened in 1947 with the construction of an airstrip at Knob Lake. A 360-mile-long railroad is being constructed from Seven Islands on the Gulf of St. Lawrence to Knob Lake and Burnt Creek. The discovery gives still greater importance to the proposed St. Lawrence-Great Lakes Seaway, over which the ore could be shipped to the steel mills on the lakes.

A MOUNTAIN OF LOGS FOR PAPER

Canada produces more paper and pulp than any other country in the world, and Quebec produces about half the nation's total. These peeled and cut logs are ready to be ground into pulp for making paper.

In the same area has been found the world's largest single deposit of ilmenite (the ore of titanium). It is at Allard Lake, 400 miles northeast of Quebec City. A railroad has been built to the deposits from Havre St. Pierre on the Gulf of St. Lawrence. A new smelting plant at Sorel treats the ore. In northwestern Quebec, near the Ontario border, is one of Canada's great gold- and copper-mining areas. Copper also occurs in the Eastern Townships and on Gaspé Peninsula.

Lead and zinc are mined chiefly at Calumet Island in the Ottawa River, northwest of Ottawa, and also in the Noranda-Rouyn area. Quebec is the world's largest producer of asbestos. The deposits are in the Eastern Townships, near the Vermont border. Thetford Mines is the oldest producing center.

Varied Manufacturing Interests

Quebec's many natural resources combine to make it an important industrial province. It has minerals; forests; water power; a river highway which permits seagoing vessels to reach large centers of population; and finally, a stable and industrious people to provide a constant labor market. In value of manufacturing output, it is second to Ontario.

First in production value is the pulp and paper industry. Quebec produces about one half the total value of this industry in the nation. Newsprint is Canada's largest export, and the city of Trois-Rivières is the world's largest manufacturer. Second in importance is nonferrous metal smelting, chiefly copper and aluminum. Quebec is one of the world's important aluminum producers, with large plants powered by hydroelectricity at Shawinigan Falls and Arvida. Manufactures ranking next in value are slaughtering and meat packing, petroleum products, and cotton yarn and cloth. Quebec provides 92 per cent of the nation's tobacco products, 72 per cent of the syn-

thetic textiles and silk, 66 per cent of the cotton yarn and cloth, 65 per cent of the women's factory clothing, and 64 per cent of the aircraft.

The provincial government encourages the development of handicrafts—weaving, wood carving, pottery making, and other crafts. Various local organizations are associated with the Canadian Handicrafts Guild, which maintains a permanent exhibit at its headquarters in Montreal. Tourists provide a ready market for these artistic products, and they are also exported to shops in the United States.

A Dual Education System

In Quebec there are two systems of education. One is French and Roman Catholic, the other is English and Protestant. School attendance in both systems is compulsory between the ages of six and fourteen. Administration is in the hands of the Council of Education in the provincial Department of Public Instruction. The council consists of a Protestant Committee and a Roman Catholic Committee. Each committee is responsible for the courses of study and textbooks within its system. Separate Catholic and Protestant school boards levy local taxes on property owners. Corporation taxes are divided in proportion to the number of Catholic and Protestant children in school.

The English-language schools have 12 grades. The four highest are known as high-school grades. In the French-language schools, boys and girls are taught in separate schools and follow different courses. Elementary education is provided in seven grades, followed by two years of primary intermediate schools. Girls leaving these schools may enter the primary superior schools for girls, or the girls' normal, or regional household science schools. Boys may enter either the technical schools, or the boys' primary superior schools which lead to higher courses of study in the commercial, normal, applied science, and polytechnical schools.

All these schools give courses corresponding to those of the high schools in the other provinces, except for classical studies. These are given only in the independent classical colleges. Students enter them from the seventh grade of the elementary schools. They offer eight years of specialized study in literature, rhetoric, philosophy, and related subjects. Most students enter the universities from the classical colleges and not from the technical and other colleges.

The leading institutions of higher learning are Laval University in Quebec City and the University of Montreal in Montreal, both Roman Catholic; McGill University in Montreal, which is nondenominational, and Bishop's University in Lennoxville, which is Church of England.

Government

As in the other provinces, the lieutenant-governor is the representative of the Crown. Actual government is in the hands of the legislature and the executive council headed by the premier. Quebec is the only province that has a bicameral legislature. The Legislative Assembly is elected by the people for a five-year term. The Legislative Council is nominated for life by the lieutenant-governor-in-council; that is, on the advice of the premier of the province.

Founded by the French

The early history of Quebec is the history of the Canadian nation (*see* Canadian History). In July 1534, Jacques Cartier erected a cross on the shores of the Gaspé Peninsula and took possession of the land in the name of the king of France. The following year he visited the Indian villages of Stadacona and Hochelaga on the sites of Quebec and Montreal.

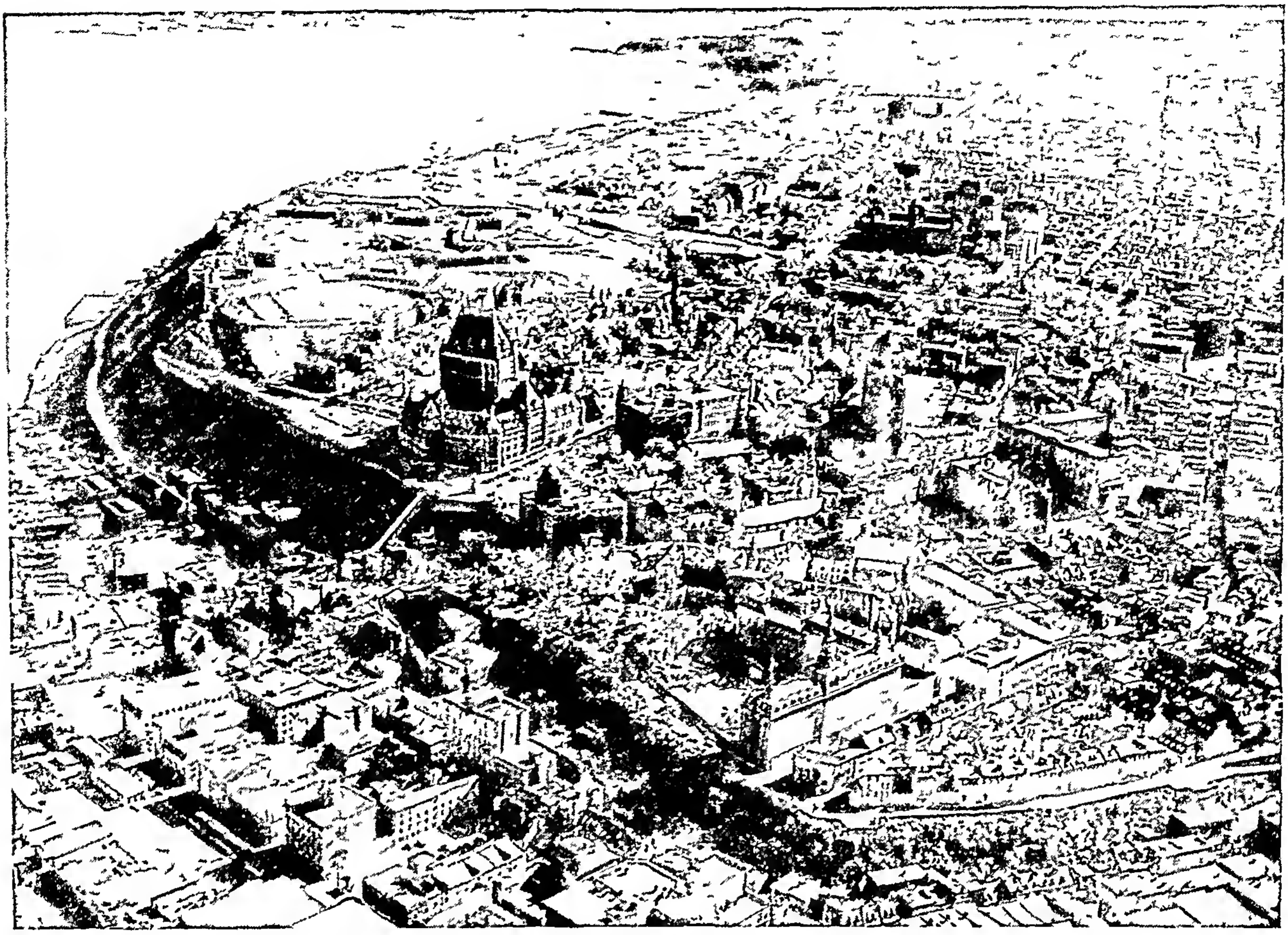
For the next 75 years Quebec shores were visited by fishermen and fur traders. In 1608, Samuel de Champlain founded the city of Quebec and established the first permanent colony. The name Quebec is believed to be an Algonquian Indian word meaning a strait or sudden narrowing. In 1634, Trois-Rivières was founded at the mouth of the St. Maurice River. Montreal was founded in 1642 under the leadership of the Sieurde Maisonneuve. For years Montreal remained the farthest outpost of the French on the St. Lawrence. Beyond and up the Ottawa River, the ferocious Iroquois Indians barred the way to settlement.

The final battle between the French and English for possession of the new world was fought on the Plains of Abraham at Quebec City in 1759. Both commanders were mortally wounded in the battle (*see* French and Indian War; Montcalm; Wolfe). By the Treaty of Paris (1763) Canada was ceded to England. Quebec was governed under the authority of a royal proclamation until the passing of the Quebec Act in 1774. By this act the French were guaranteed freedom of worship and property rights under the French civil law. During the American Revolutionary War Quebec was invaded, but under the leadership of Gov. Guy Carleton the Americans were driven back.

In 1791 Quebec was divided at the Ottawa River into two colonies known as Upper and Lower Canada, corresponding to modern Ontario and Quebec. In 1837, under the leadership of Louis Joseph Papineau, Lower Canada rebelled against the abuses of the governing party ridiculed as the "Chateau Clique" (*see* Papineau). At the same time, Upper Canada, under William Lyon Mackenzie, was inflamed against the "Family Compact." Both rebellions failed, but they led in 1840 to the union of the two colonies as the Province of Canada. Until Confederation in 1867, Quebec was known as Canada East.

In 1912 the area of Quebec was doubled by the addition of the immense northern territory then known as Ungava. The British Privy Council in 1927 placed the boundary between Labrador and Quebec along the watershed of the rivers flowing to the Atlantic. By this decision Quebec lost 112,630 square miles.

Three of Canada's prime ministers have been French Canadians from Quebec—Sir George Étienne Cartier, Sir Wilfrid Laurier, and Louis St. Laurent (*see* Laurier; St. Laurent). In both World Wars the people of the province made notable contributions. The postwar period has been marked by industrial expansion. (For Reference-Outline and Bibliography, *see* Canada; Canadian History.)



This view of Quebec, looking upstream, shows the lower town on the river's edge and the walled-in upper city. The Citadel (upper left) is on the highest point of Cape Diamond. The turreted building (left center) is the Château Frontenac, a hotel. Between them, skirting the bluff, is Dufferin Terrace. The group of buildings (lower right) is Laval University.

The GREAT WALLED CITY *on the* ST. LAWRENCE RIVER

QUEBEC, CITY OF. Where the broad estuary of the St. Lawrence River closes in around the Isle of Orleans and then narrows to less than a mile, there rises the massive gray rock of Cape Diamond. Here Samuel de Champlain founded the city of Quebec in 1608. For more than 150 years it guarded the struggling colony. Then in 1759 the sprawling French empire in the New World began to dwindle when the British under Gen. James Wolfe defeated Louis Montcalm, the French general, on the Plains of Abraham west of the city. In the treaty of Paris in 1763 France ceded Canada to Great Britain. But under both French and British rule Quebec was long the capital of Canada, and it is now the capital of Quebec province.

Quebec lies on the north bank of the St. Lawrence at the northeastern extremity of a rocky tableland. The bluff rises from the water's edge to a height of about 350 feet at Cape Diamond, the highest point in the city. On the landward side the tableland slopes gently to the valley of the St. Charles River. This stream empties into the St. Lawrence north of the cape, forming a fine harbor.

Reminders of a Bygone Age

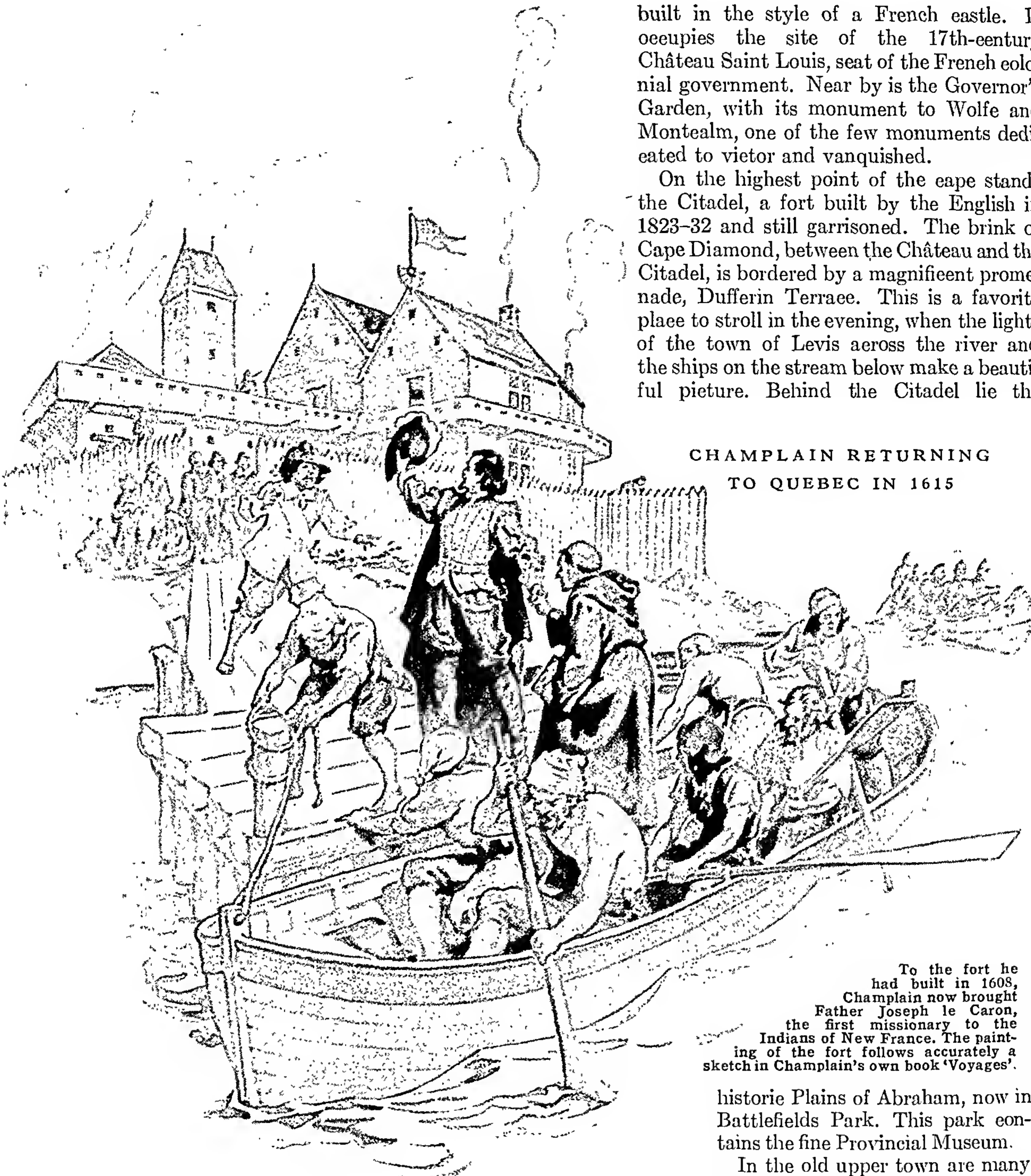
The approach by ship from the northeast is one of dreamlike beauty. The rock sweeps strongly skyward, its feet bathed in the soft gray mists that drift over the river in summer, its summit crowned by slender church spires glittering in the sunlight. The low massive walls of the Citadel and the turrets of Château Frontenac lend a feeling of timelessness, as though rock and city would endure forever. No other city north of the Rio Grande preserves unchanged so many features of the life of a bygone age. Its "foreignness" is emphasized by the fact that nine-tenths of the people are of French origin, and French is the language of everyday life.

Quebec is divided into an upper and a lower town. The two sections are connected by steep streets, flights of stairs, and a municipal elevator. The lower town huddles at the foot of the cliff on a narrow strip by the river's edge. Its houses and shops, with their steep-pitched roofs and dormer windows, and its narrow streets resemble those in the old sections of Normandy and Brittany. An interesting building is the Church of Notre Dame des Victoires, erected in 1688. Its name commemorates the defeat of British invaders in 1690 and again in 1711.

In the streets mingle nuns and priests in the costumes of long ago, soldiers from the Citadel, and sailors of all nations. Boys from Le Petit Séminaire

built in the style of a French castle. It occupies the site of the 17th-century Château Saint Louis, seat of the French colonial government. Near by is the Governor's Garden, with its monument to Wolfe and Montcalm, one of the few monuments dedicated to victor and vanquished.

On the highest point of the cape stands the Citadel, a fort built by the English in 1823–32 and still garrisoned. The brink of Cape Diamond, between the Château and the Citadel, is bordered by a magnificent promenade, Dufferin Terrace. This is a favorite place to stroll in the evening, when the lights of the town of Levis across the river and the ships on the stream below make a beautiful picture. Behind the Citadel lie the historic Plains of Abraham, now in Battlefields Park. This park contains the fine Provincial Museum.



CHAMPLAIN RETURNING TO QUEBEC IN 1615

To the fort he had built in 1608, Champlain now brought Father Joseph le Caron, the first missionary to the Indians of New France. The painting of the fort follows accurately a sketch in Champlain's own book 'Voyages'.

In the old upper town are many churches and convents. One of the most famous of these is the Cathedral of Notre Dame, called the Basilica. Begun in 1647, it was destroyed by fire in 1922 and was later rebuilt. In the nave of the Ursuline Convent chapel, built in 1639, repose the bones of Montcalm. A hospital, the Hotel Dieu, was also founded in 1639. The Cathedral of the Holy Trinity, built in 1801–04, is the oldest Anglican Cathedral in Canada. Laval University is one of the seats of French-Canadian culture. It is maintained

wear long blue coats, piped with white and broad green sashes. The picturesque *calèche*, a two-wheeled horse-drawn carriage, and the sleigh in winter have not yet entirely given way to the automobile.

The upper town is surrounded by heavy walls, built by the British in the early 19th century. Quebec is the only walled city in North America. On the outermost point of the cape, commanding a superb view of the river, stands the Château Frontenac, a hotel

by the Quebec Seminary, founded by Bishop Laval in 1663. In the Upper Town also are fine shops and modern office buildings.

Beyond the walls, to the west, are the buildings of the provincial parliament. The residential district now lies outside the walls to the west, along the Grande Allée, and across the St. Charles River to the north.

An Important Seaport

Quebec is one of the chief ports of Canada. Louise Basin, at the mouth of the St. Charles River, and Wolfe's Cove are lined with wharves and docks which can accommodate the largest vessels. The western development of the country transferred most of the export trade of the province to Montreal. But as ocean-going ships increased in size, it became more difficult for them to ascend the river, and some of the commerce returned to Quebec. The city is also a terminal port for transatlantic passenger liners. The harbor is closed by ice for three to four months every winter.

Power for manufacturing is provided by great hydroelectric plants at the near-by Montmorency and Shawinigan falls. The leading products include pulp and paper, paper boxes, boots and shoes, brick, and tobacco. The Quebec bridge, about ten miles upstream, permits railroads from the south to enter the city. Ferries operate across the river to Levis. A suspension bridge connects the mainland to picturesque farm communities on the Isle of Orleans, which extends downstream about 15 miles.

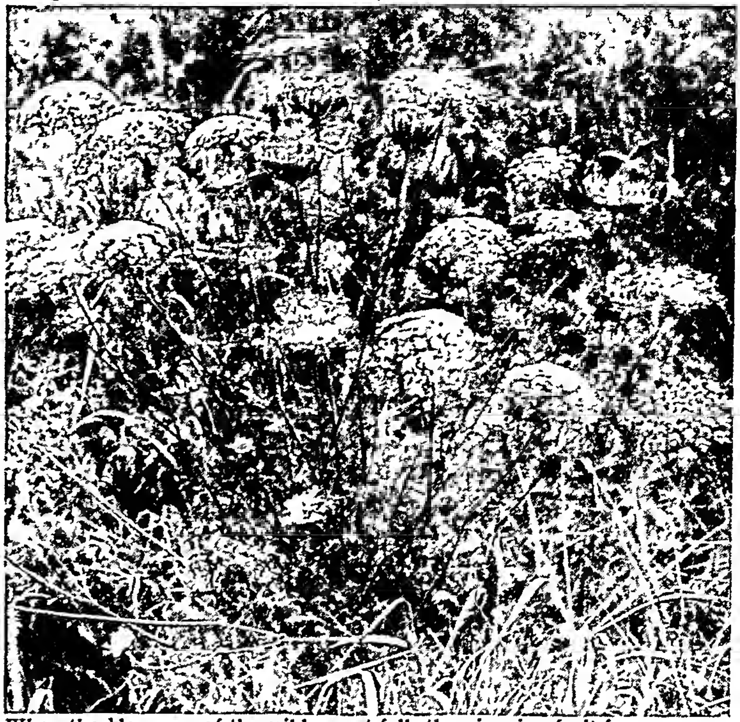
The history of Quebec begins with the visit of the navigator Jacques Cartier, in 1535, who found here the large Indian village of Stadacona. In 1608 Samuel de Champlain founded the first settlement below the heights and called it Quebec. The name is believed to be an Algonquian word meaning a strait, or sudden narrowing. Quebec finally passed into British hands after the campaigns in 1759 (*see* French and Indian War; Montcalm; Wolfe). In 1775, during the American Revolution, it was unsuccessfully attacked by Gen. Richard Montgomery and Benedict Arnold. Population (1951 census), 164,016.

QUEEN ANNE'S LACE. The tiny flowers of the wild carrot grow in umbellets ("little umbrellas") to form a flat-topped cluster that looks like lace. They give the weed its prettiest nickname—Queen Anne's lace. The flowers usually are white, but they may be faint pink or pale greenish-yellow. The central flower of each cluster is sometimes purplish.

Queen Anne's lace is hardy and spreads rapidly. If given a chance, it crowds useful grasses from fields and pastures. This trait has given it another nickname, "devil's plague." The best way to control the weed in farming areas is to plow under all fields where it has taken hold. This should be done just before the plants are ready to bloom.

The wild carrot, like the garden carrot, belongs to the parsley family (*Umbelliferae*). It is widespread in America and thrives especially in northeastern United States. It also grows in the temperate regions of Europe and Asia. The plant grows from 1 to 3 feet tall. Flower clusters are usually 3 to 5 inches across. The leaves are small and cleft two or three times almost to the central rib. The outer divisions are sharply cut and pointed. Scientific name, *Daucus carota*. (For additional pictures, *see* Flowers.)

QUEEN ANNE'S LACE, THE WILD CARROT



When the blossoms of the wild carrot fall, the ripening fruit forms a cup-like bristly cluster. A popular name for this cluster is seed basket. It gives Queen Anne's lace two more nicknames—bird's nest weed and crow's nest. Here we see several seed baskets beginning to form.

QUEEN ANNE'S WAR. The second major war waged by France and England to rule America was Queen Anne's War, 1702–13. This struggle for power began just five years after their first contest in King William's War (*see* King William's War).

Again both English and French used Indians as allies. The chief battleground in Queen Anne's War was the New England frontier. French and Indian raids terrorized lonely villages. In 1705 a hardy force of some 450 trekked on snowshoes to capture St. John's. As the war dragged on, English sea and land forces attacked Newfoundland and Acadia. In 1710 they seized Port Royal and all Acadia, which they renamed Nova Scotia. The war was costly to France, because the Peace of Utrecht in 1713 gave all Nova Scotia and Newfoundland to England.

Queen Anne's War was part of a larger conflict called the War of Spanish Succession, which raged in Europe. This conflict began when Louis XIV of France in 1700 made his grandson king of Spain as Philip V. Fearing the rising French power, England joined Austria, Holland, and Portugal in campaigns against France in 1701. After Queen Anne came to the English throne in 1702, formal war was declared. It did not end until the Peace of Utrecht in 1713.

CATTLE COUNTRY OF QUEENSLAND

This scene in southern Queensland might be duplicated in the wooded highlands of Texas. Both regions raise cattle and sheep and have similar climatic and agricultural conditions.

QUEENSLAND, AUSTRALIA. The entire northeastern portion of Australia, 670,500 square miles, is included in the state of Queensland. The population is scanty, 1,106,269 (1947 census), less than two persons for every square mile. Ninety-three per cent of the area is still the property of the British crown; most of this land is leased for grazing. Only about one acre out of 400 is under cultivation. Corn, wheat, and sugar cane are the most important crops. Silver, gold, coal, and other minerals are mined, and considerable quantities of timber are cut from the immense forests which cover much of the state; but scarcity of labor has hindered the development of Queensland's abundant resources.

More than half of Queensland lies within the tropics. The winter, which is practically rainless, is about as warm as an English summer. The summer, when the heavy rains occur, is warmer, but extremes of temperature are almost unknown. Most of the northern coastland is tropical forest, with luxuriant palms, tree ferns, bamboo, and screw pine. Pineapples, bananas, and other tropical fruits are raised. Farther inland, where rainfall is scanty, are the grassy lands with their famous sheep walks and cattle runs. More than a third of the cattle in Australia are in Queensland, and the dairying industry is rapidly growing. Manufactures are still of comparatively little importance Brisbane, the capital, with a population of 402,172, is the only city of any considerable size It is an important shipping point and is the seat of a university established in 1911. (*See* Australia.)

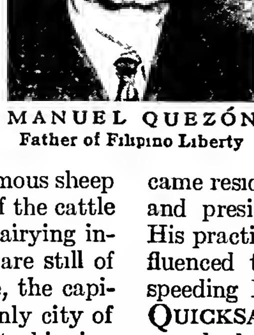
QUETZAL (*kĕt-sal′*). For gorgeous plumage few birds surpass the quetzal of Central America and Mexico, the national bird of Guatemala. The male, hardly as large as a mourning dove, has tail coverts elongated into a golden green train more than three feet long. His underparts are crimson; the rest of his plumage, brilliant green. The less colorful female lacks the long tail plumes. Among the early Indian tribes of this region the quetzal was an emblem of royalty and religion, and only chiefs and priests were allowed to wear the bird's plumes. The death sentence was passed upon any person killing a quetzal. Scientific name, *Pharomacrus mocinno.*

BIRDS OF ROYALTY

Plumage hunters have nearly exterminated quetzals.

QUEZÓN (*kā-sōn′*), **MANUEL** (1878-1944). Fiery Manuel Quezón might well be called "father of his country." He spent his life striving to win independence for the Philippine Islands. As a young student he fought in insurrections against Spain and the United States. Then he turned to politics. His work for freedom made him the Filipino leader, and in 1935 he became first president of the Philippine Commonwealth.

Yet Quezón did not live to see the birth of the Republic of the Philippines, July 4, 1946. He died in 1944 during the second World War while Japan still held the Philippines. He and his government were in exile in the United States, waiting until America's armed forces could liberate the islands (*see* Philippine Islands; World War, Second).



MANUEL QUEZÓN
Father of Filipino Liberty

Quezón was born in Baler, on Luzon Island, Aug. 19, 1878. He was the son of a Filipino schoolteacher father and a half-Spanish mother. A brilliant lad, he was educated in San Juan de Latran college and the law school of the University of Santo Tomás in Manila Shrewdness, charm, a gift for oratory, and a flair for showmanship quickly brought him success in politics. He became resident commissioner in Washington (1909–16) and president of the Philippine Senate (1916–35). His practical diplomacy and persuasive eloquence influenced the United States Congress to pass laws speeding Philippine independence.

QUICKSAND. Quicksand is a mass of fine, smooth, round-edged particles of sand so separated by constantly moving water that the sand will not support any weight. Quicksand is usually found in hollows at

the mouths of large rivers or along flat stretches of streams or beaches where pools of water become partially filled with sand and an underlying layer of stiff clay or other dense material prevents drainage. Mixtures of sand, mud, and vegetation in bogs often act like true quicksands.

Fiction and folklore give spectacular accounts of men and animals clutched and swallowed up by quicksand. Its real treachery, however, lies in its surface resemblance to solid sand formations rather than in any mysterious power to suck its victims down. Any body will float in quicksand much as it does in water unless frantic struggles to release the feet create downward suction. Jerking movements cause the sand first to give way and then to pack in again around the body like a vise.

A man who finds himself in quicksand should remain motionless with his arms outstretched. He will stop sinking as soon as his weight equals the weight of the sand he has displaced. Usually he will stop when the sand reaches almost to his armpits. Then with slow, deliberate swimming motions of the arms, but with the feet held perfectly still, he should try to ease his body forward and into a horizontal position. In this position, with his weight distributed evenly over the surface of the sand, he should be able to roll to firm ground. Above all, he should retain presence of mind and not become panic-stricken. If a companion is present, he can use a stick or branch to poke into the quicksand and thus break the vacuum that is sucking the trapped person down. (*See also* Sand.)

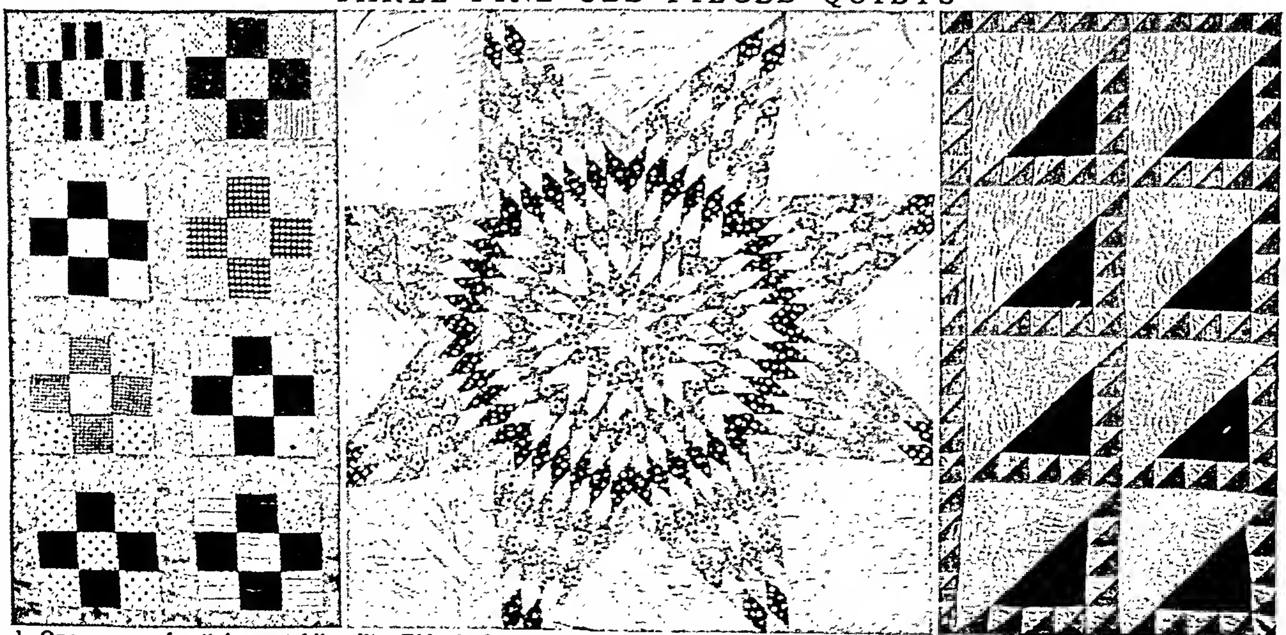
BREAKING QUICKSAND'S BINDING GRASP

To rescue a person trapped in quicksand, his companion should remain on firm ground and poke the end of branch below the victim's feet. This will introduce air to break the vacuum that sucks down and holds him fast.

QUILTS. The art of quilt making in America was born of necessity. The first colonists had only the bedclothing they had brought from home. Nights in the new land were cold, and cloth for coverlets was rare. Pioneer women cut all bits of good material from worn-out garments and sewed them together, regardless of size and shape, into "crazy quilts."

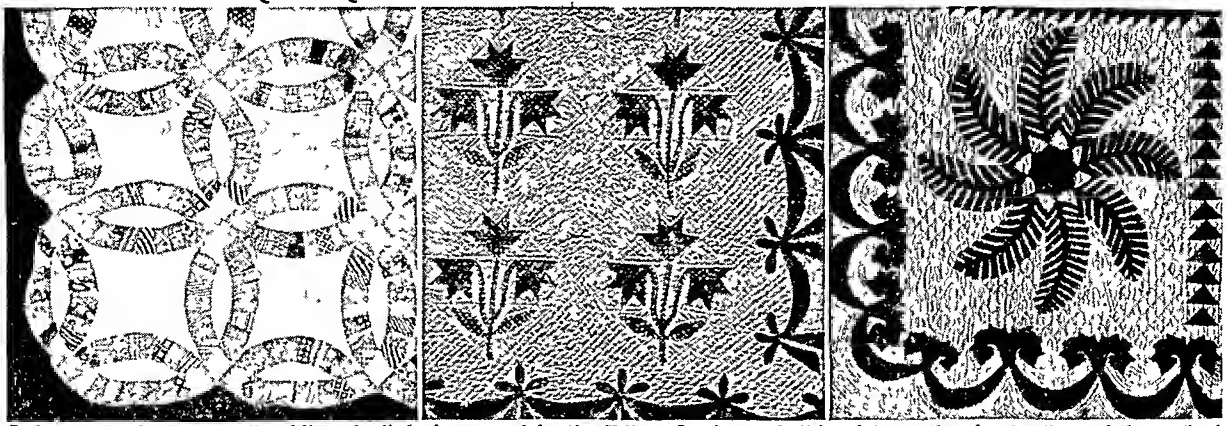
As pieces became more plentiful, women cut them into squares or oblongs of uniform size and sewed

THREE FINE OLD PIECED QUILTS



1. One corner of a "nine-patch" quilt. This design gets its name from the nine small squares that make up each larger square.

APPLIQUÉ QUILTS IN THREE WELL-KNOWN DESIGNS



Left, corner of a quilt in "wedding ring" design owned by the Edison Institute. Quilting follows the circular lines of the appliqué pattern. Center, "North Carolina lily" repeated in an all-over design with a border of lover's knots. Quilting is in diagonals. Right, "princess feather" or "ostrich plume" design with motifs separated by "cat tracks." Quilting is a combination of shell and leaf or flower design. The "lily" and "feather" quilts are in the collection of the Art Institute of Chicago.

them together into "hit or miss" quilts. Presently they began to sew their squares and oblongs into "Roman stripe," "brick wall," and "log cabin" designs. Then they combined triangles and diamonds into stars and other patterns. These early *pieced* quilts were almost all geometrical in design.

The *appliqué* quilt appeared about 1750. In this type, the quilt maker works with large rectangles, or blocks, of material which will make up into a quilt of the desired size. She applies colored pieces to these blocks to form a design, turning under the edges of the applied pieces and hemming them down with tiny stitches. Women sought designs for appliqué in familiar things—flowers, fruit, leaves, and so on. Some of the finest appliqué quilts were made in the Middle West in the 19th century. Making such quilts is a popular handicraft today

The terms *pieced* and *appliqué* refer only to the tops of the quilts. Each quilt also has a lining and an interlining. The name "quilt" comes from the method of fastening these layers of material firmly together. Lining, interlining, and quilt top are stretched taut on a quilting frame. Then the quilter works out a design in tiny running stitches through all the layers. At the old "quilting bees" 12 women might work at one quilting frame and several frames be in use.

QUINCE. Although the quince lends a delightful flavor to jellies and preserves, it is bitter to the taste when raw. The common quince (*Cydonia vulgaris*) is a many-branched shrub or small tree closely related to the apple. Its large white or pink flowers resemble apple blossoms. They are followed by hard golden-yellow apple- or pear-shaped fruit. (For illustrations in color, *see* Fruits.) It is widely cultivated in the Northern Hemisphere. The best orchards are in New York State. The quince is native to Iran (Persia) and Anatolia and possibly to Greece. It played a part in Greek legends.

The Japan quince (*Cydonia japonica*) is grown in gardens for the beauty of its early spring flowers. They vary from creamy white to rich red. Its green fruit is fragrant but uneatable.

QUININE. For three centuries quinine, obtained from the bark of the cinchona tree, was one of the most valuable of all drugs. It was the only satisfactory means of treating malaria. Today there are a number of man-made substitutes for this drug.

The cinchona tree is a native of South America. The Spanish conquerors of Peru discovered the curative power of its bark about 1640. Powdered cinchona bark became so popular in Europe for the treatment of malaria that the demand was enormous. Cinchona trees were ruthlessly cut down and stripped of their bark. Within two centuries South America had almost exhausted its supply Dutch colonists introduced the tree in Java about 1850. By the time the second World War broke out, 90 per cent of the world's quinine came from the East Indies. Seizure of this area by the Japanese in 1942 spurred research among the Allies for quinine substitutes.

The first of these to go into large-scale production was quinacrine (trade name, atabrine), a coal-tar derivative which originated in Germany. Chemists at Harvard University made synthetic quinine in 1944. Other synthetic antimalaria drugs are pentaquine, pamaquine, chloroguanide, and chloroquine.

Chemically, quinine is a white crystalline alkaloid. It kills all forms of the malaria parasite except the sexual form of *Plasmodium falciparum*, which causes the tertian form of malaria (*see* Mosquito).

QUOITS. Tossing an iron ring at a stake has been a popular sport since ancient times. Two modern games of this type are *quoits* and *horseshoes*. Quoits are flattened iron rings that weigh about nine pounds. Each player pitches two quoits at a one-inch stake (*hob*) 18 yards away. A quoit that encircles the hob counts two points (*ringer*). If there are no ringers the nearest quoit, within 18 inches of the hob, counts one point. A game is 21 points. Aboard ship, *deck quoits* are played with rings of rope.

Horseshoes are pitched in the same manner. The stakes are 12 inches high and are set 40 feet apart. A ringer counts 3 points. The nearest "shoe," within six inches of the stake, counts one point.

R

RABBITS AND HARES. Among the best-known wild animals are the cottontails and jack rabbits. They are abundant in the brushy woods and gardens of eastern North America, on the western plains and deserts, on mountains, and even in the Arctic snows. People know about rabbits from many stories about them, and the Easter rabbit is a familiar symbol of new life. But few people know that many of the animals they call rabbits, like the jack rabbit and snowshoe rabbit, are really hares.

It is not easy to tell rabbits from hares. The hare is larger and heavier and has longer ears. With its longer hind legs and larger hind feet, it can outjump any rabbit. Also it does not tire as quickly. Many hares turn white in the winter. Rabbits keep the same colored coat the year around.

Hares and rabbits bear their young in very different ways. The female hare (called a *doe*) has two or three litters of young a year, with from four to six babies in each litter. She does not make a nest for her young. They are born in a flattened area called a *form* in the grass beneath a low branch or under a brush heap. Young jack rabbits may lie directly on the desert ground, in the shade of a cactus or some other plant. Young hares are born with their eyes open and with dense fur on their bodies. They can care for themselves within a few days.

A mother rabbit does much more for her young. She provides a nest by scraping out a hollow in the grass or moving into an old woodchuck hole. Best of all she likes a burrow beneath a large tree with the entrance between the roots. Then her enemies cannot dig her out.

She lines the nest with finely shredded leaves and grasses and pads it with a warm blanket of fur pulled from her own coat. The young are born blind, naked, and helpless. The mother feeds the babies with her milk. When she goes for her own food, she hides the nest with leaves or grass.

A FAMILY OF HARES AMONG THE DAISIES

A varying hare watches over her five babies in their simple nest of flattened grasses, called a "form." These little ones may be only a few days old. They are born with their eyes open and with a heavy coat of fur. They feed on their mother's milk for the first few days. Then they venture out of the nest to nibble on grasses and other green plants.

The babies open their eyes in about a week. In 10 or 12 days they leave the nest. By the time they are three weeks old they can care for themselves. Rabbits have many litters, from early spring to late fall. There are from four to six young in each litter. In the Southern states, rabbits bear young throughout the year. Male rabbits and hares (called *bucks*) pay no attention to the young.

Rabbits and hares are gnawing animals like rats, mice, and squirrels, and they have the same type of strong, chisel-like front teeth. When a cottontail or jack rabbit eats it nips off a plant leaf at the base, settles back, and lifts its head. Then a sideways chewing motion of the jaws slowly draws the food into its mouth.

Eyes and Ears Alert to Danger

A rabbit or hare is well equipped to detect enemies. The long ears are very sensitive. Therefore these animals should never be lifted by their ears. They should be picked up by the loose skin of the neck with one hand while the other hand supports the body under the hind legs.

When the animal is at ease the ears lie quietly along its back. But at the slightest sound they stand upright, waving backward and forward as they try to locate the danger. The nose too is sensitive. As the animal tries to get a scent it twitches the nostrils and moves the head up and down in a worried manner.

Large eyes are located on either side of the head. Each eye sees more than half a circle, and together they see in every direction. Thus they can watch an approaching hawk overhead and at the same time look for a brush heap to dash into for shelter.

Their upper lips are split. That is why a deformity in the upper lip in human beings is called "harelip." The tail is short, and in most rabbits and hares it stands erect. They have five toes on their forefeet and four on the hind feet. But the paws cannot turn inward to be used as hands like those of mice and squirrels.

Rabbits and hares feed at night and remain in the nest or form during the day. They are fond of all green growing things and do great damage to gardens and field crops. In the winter they feed on the bark of trees and shrubs, on buds, and on berries.

In turn, they are the chief food of many animals, such as wolves, coyotes, lynxes, foxes, mountain lions, and wild cats. Owls and hawks prey on them, and red squirrels attack their young. Millions are killed by hunters every year. Among the game animals, they are second to deer in the value of their meat.

How They Get Their Speed

To escape enemies, rabbits and hares rely chiefly on speed. When a hare or rabbit takes to flight it leaves the ground with a tremendous leap. For an instant its body is stretched out in a straight line. Then, while still in the air, it brings its hind legs forward until they reach beyond and above its head.

While it is bunched in this position, its fore paws strike the ground, one ahead of the other. An instant later the hind legs strike on each side and ahead of the forefeet. Thus the animal is "coiled up" almost like a spring. It "uncoils" suddenly to make its next great leap. The tracks left by the feet form a pattern like a human face. The marks are blurred, because the feet are furry.

A frightened jack rabbit covers from 15 to 20 feet at a bound. Cottontails jump little more than eight feet, and they tire more quickly. Traveling at top speed, they may stop suddenly and jump in another direction. This trick has driven pursuing dogs headlong into barbed-wire fences and even over cliffs.

Hares and rabbits are timid, but they fight bravely in defense of their young and in self-defense. They may leap over the back of another animal or a snake, and give it a fierce kick with the hind legs. And they bite if necessary.

A Menace to Crops

In spite of all their foes, rabbits and hares may increase rapidly enough to overrun large areas and destroy entire crops. In 1850 three pairs of the European rabbits were turned loose in Australia. Within a few years Australians wondered whether the descendants could be checked before they swept the country clean. Millions of dollars were spent for bounties and for devices for killing the rabbits or protecting the crops. New Zealand had a similar experience a few years later (*see* Australia).

In the western United States jack rabbits increase enormously in numbers in five- to ten-year cycles and cause great damage to crops. At such times thousands are killed by poisoning and by organized drives in which whole communities take part.

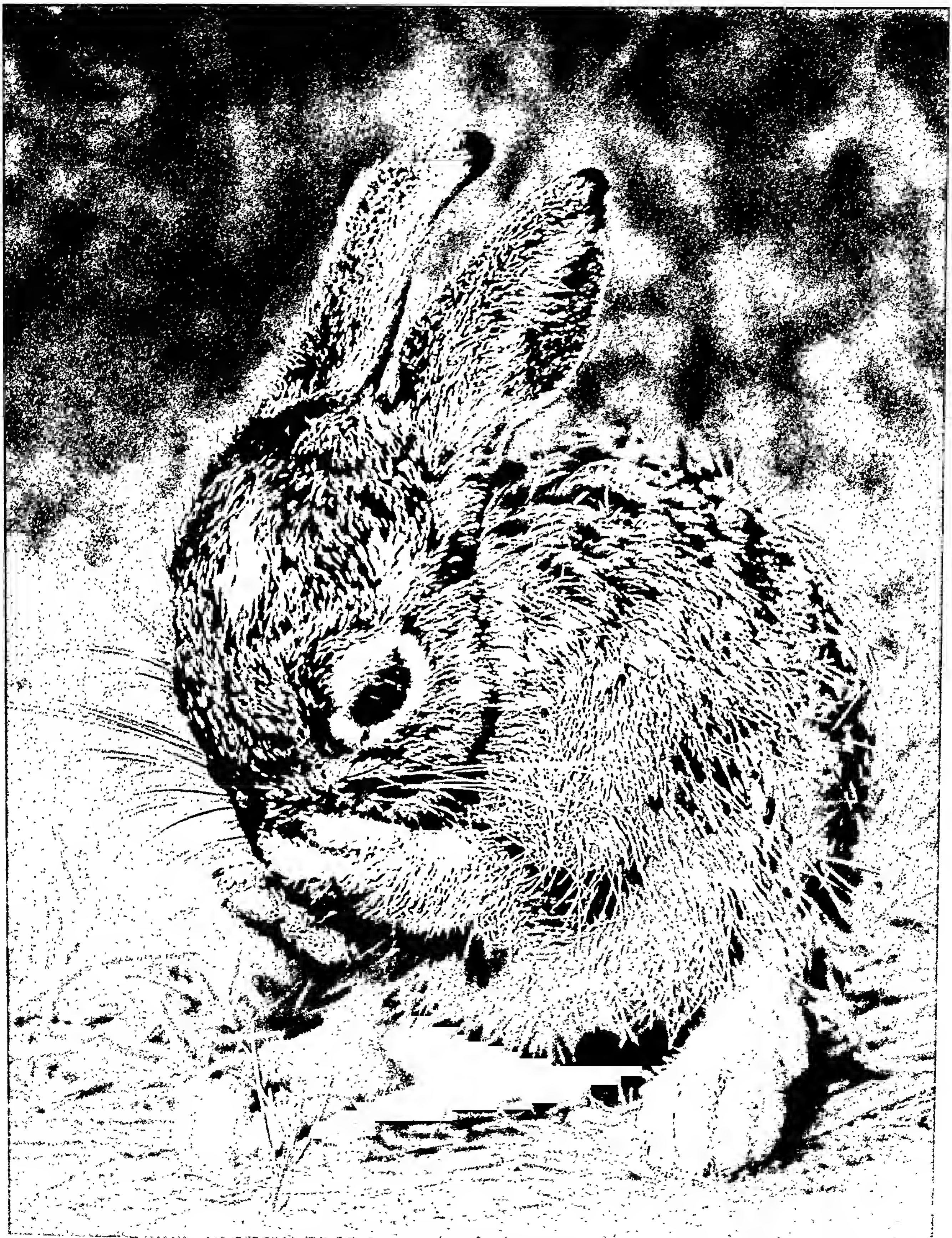
Cottontails and Other Rabbits

Cottontail rabbits inhabit much of the Western Hemisphere from southern Canada to South America. The animal gets its name from the fluffy snow-white underside of its tail. Cottontails vary from 14 to 18 inches in length and weigh from two to three pounds. Generally they are brown with buff sides and white under parts.

They live in any kind of country where they can find brushy shelter. Under the brush they make trails by nibbling off plants at the base. Only a rabbit can see the trails in the summer, but they become very noticeable in the winter. Hunters often place snares across them. Along the trails each rabbit sits quietly in a form during the day, dozing, washing itself, but always alert for danger. When it is frightened it stamps the ground with a hind foot, perhaps to warn other rabbits. Probably they can feel the vibrations or hear the thumping.

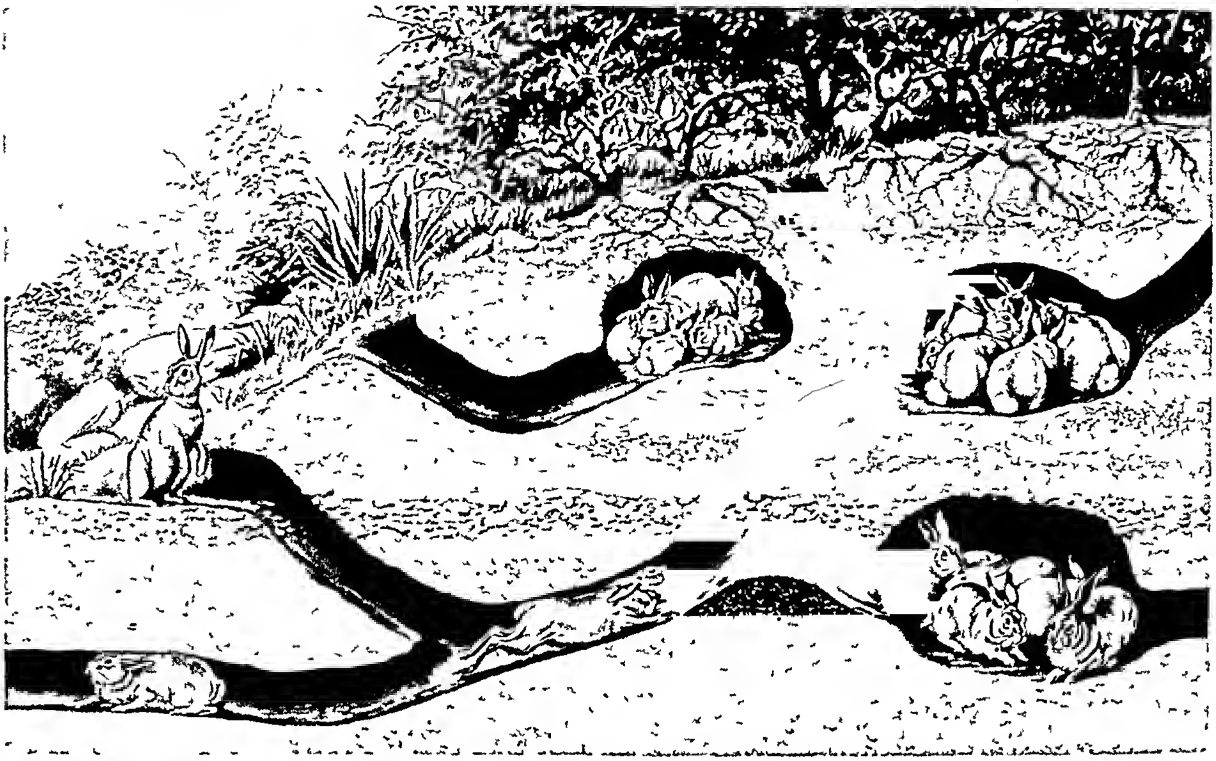
American rabbits live alone. Rarely does anyone see two cottontails together. Each rabbit occupies two or three acres and knows every square inch of it. European rabbits are quite different. They live in colonies in underground burrows called *warrens*. This rabbit has been introduced into the United States and is increasing in numbers in the Eastern states. The Southern states have swamp and marsh rabbits. They are darker than the cottontails, and their tails do not have the white underside. These rabbits are

A BABY JACK RABBIT WASHES ITS FACE



This little jack rabbit is trying very hard to wash its face with its front paws. They hardly seem long enough for the job. Unlike a cat, it washes with both paws at once. A rabbit cleaning itself is an amusing sight. First it shakes each foot violently to free the dirt and then licks it off. It cleans its ears by pushing them forward with the hind feet within reach of the tongue.

UNDERGROUND LIFE IN A EUROPEAN "RABBIT TOWN"



European rabbits are sociable creatures. They form colonies in burrows called "warrens." Most of the passages are connected together with little side "pockets" in which individual families dwell. Mother rabbits, however, usually have separate burrows, as you see in the upper part of the picture, until the little ones are well grown. The main warren always has two or more entrances so that if enemies such as weasels and ferrets come in one door, the inhabitants can run out through another. Usually the entrances are made behind the concealing protection of a bush or rock.

good swimmers. They do little harm to farmers, for they live on water plants, especially cane. They are known locally as "cane cutters."

Jack Rabbits and Other Hares

The jack rabbits are the largest and best known of the American hares. They are more than two feet long and their ears are from five to six inches long. They weigh four to six pounds. Black-tailed jack rabbits are common on the open plains of the West from Saskatchewan to Mexico. The white-tailed jack rabbits (prairie hares) live on the plains with the black-tail, but they range farther north and higher in the mountains. They are larger and weigh six to eight pounds. This hare changes its grayish-brown coat for a white pelt in winter.

The varying hare ranges from the northern United States to the Arctic Circle. It is also found in the Appalachian Mountains. It is intermediate in size between the white-tail and black-tail jack rabbit. It is called a varying hare because it sheds its fur twice a year, becoming white in the fall and brownish-gray in spring It is also called the snowshoe rabbit because in winter its large hind feet are covered with thick fur. This enables it to travel easily over soft, deep snow. The Arctic hare lives in the far north. In the northern part of its range it keeps its heavy white coat throughout the year.

The European hare inhabits all parts of Europe except Ireland, Scandinavia, and northern Russia It is 20 to 22 inches long and weighs six to eight pounds.

The Alpine hare, also called the blue or mountain hare, resembles the Arctic hare of America It is found in Scandinavia and northern Russia. Another species of hare lives only in Ireland.

Commercial Rabbit Raising

Rabbits are raised commercially for their meat and their fur. Southern California is the leading producer, followed by Colorado, Ohio, and New York. At Fontana, Calif., the United States Fish and Wildlife Service maintains the only Rabbit Experiment Station in the country.

Rabbit meat is usually sold cut up in frozen packages, and ready for frying or roasting. Fryer rabbits are slaughtered when they are about two months old. Older does and bucks are sold as roasters. The better grades of fur, called *cony*, are used for making coats and trimmings. The cheaper grades are used in the manufacture of felt hats and as linings for gloves and other objects. Many pelts are imported from Australia, New Zealand, France, and Belgium.

White rabbits are the most popular commercial type because their pelts bring higher prices than the dark breeds. The white rabbits best suited to meat and fur production are the Flemish giant, New Zealand, American, Beveren, French Silver, and Chinchilla Angora rabbits are raised for their long, fine wool This is spun into yarn for sweaters and scarves Another popular breed is the Belgian hare (really a rabbit). The Patagonian is one of the largest, weighing from 12 to 16 pounds. The lop-eared

rabbit has ears which are from 10 to 12 inches long and 6 inches wide. They hang down beside the head.

Among tumbling rock slides, high in the mountains of Europe, Asia, and Western North America, lives the pika, a close relative of the hares and rabbits. Its short legs, small rounded ears, and stumpy tail make it look like a small guinea pig. Its voice is a peculiar "bleat" unlike any other mammal. Pikas believe in making hay while the sun shines. All summer long they pile up stacks of dried grasses for feed during the winter months.

Scientific Classification of Rabbits and Hares

Because of their gnawing teeth, rabbits and hares once were classified as rodents (*Rodentia*). But they differ from the others by having two small incisors (cutting teeth) behind the larger ones in the upper jaw. For this reason scientists now place them in a separate order, the *Lagomorpha*.

Within the order *Lagomorpha*, rabbits and hares belong to the family *Leporidae*. Scientific name of eastern cottontail rabbit, *Sylvilagus floridanus;* of marsh rabbit, *Sylvilagus palustris;* of swamp rabbit, *Sylvilagus aquaticus;* of black-tailed jack rabbit, *Lepus californicus;* of varying hare, or snowshoe rabbit, *Lepus americanus;* of white-tailed jack rabbit, *Lepus townsendii;* of Arctic hare, *Lepus arcticus;* of European common hare, *Lepus europaeus;* of Alpine hare, *Lepus timidus;* of European rabbit, *Oryctolagus cuniculus.* The pika belongs to another family, *Ochotonidae;* scientific name, *Ochotona princeps.*

RABELAIS, FRANÇOIS (*rä-bĕ-lā', fräns-wä'*) (1493?–1553). The hearty, jibing, racy, and often most improper stories of this famous French humorist are favorites even today, down four centuries of time. While pretending to tell a tale about the adventures of two giants, Gargantua and Pantagruel, Rabelais makes huge fun of the vices and foolishness of the people about him and of abuses within the church. His humor is at times so shocking, and his stabs at the church so deep, that it is hard to believe that for most of his life he was a member of the clergy.

Rabelais became a brother of the order of St. François in the convent of Fontenay-le-Comte in western France, about 1519. There he pored over many great volumes and learned many strange languages. The other monks began to fear and suspect the young wiseacre, and they charged him with heresy. In wrath he whisked himself and his monk's robes out the door and down the dusty highway to begin the life of a vagabond. He wore his pious costume all his life.

A few years later Rabelais settled at Montpellier in the south of France to study medicine. He lectured in the university there and, in 1530, became physician of the hospital. About this time he won the friendship of Jean du Bellay, who was later made a cardinal. When Bellay went to Rome in 1534, Rabelais was a member of his retinue. Bellay persuaded the pope to pardon Rabelais for his abrupt departure from the monastery. Later, also through the good offices of Bellay, he was given "livings" in the Church of France. This lifted him above the fear of want.

During a period of religious persecution in 1547, he fled to Metz, and as physician gained a humble fame among the poor. In 1552 he published his fourth book about Pantagruel, resigned his living, and went to Paris. There he died the next year, murmuring, "I go to find the great *Perhaps*."

The precise year of Rabelais' birth is not known. In his half-vagabond life he made the acquaintance of every tramp and trudging workman along the road, of the great men of the church, and of the king and his court. From such a life was distilled the wide sympathy with all men, the rowdyism, the cleverness, and the liveliness which make his writings still read today.

Rabelais' great satire 'Gargantua and Pantagruel' was published in sections. The first appeared in 1533. The complete edition was first published in 1567. He also edited various works.

RACCOON. Of all the wild animals, the raccoon seems to get the most fun out of life. Intelligent, curious, and restless, it looks constantly for something new to do. It is about the size of a cocker spaniel. Its rolypoly body is covered with thick gray-brown fur and its long bushy tail is ringed with black and white. The raccoon has a black mask across its eyes, and its narrow muzzle sprouts saucy whiskers. It can be found almost anywhere from Central America to southern Canada.

Raccoon families live in hollows high in tree trunks near a pond or stream. In April or May, from three to six young are born. The parents keep them about a year. When they are no larger than kittens, their mother teaches them to claw the bark with their long five-toed feet and to climb down the trunk. From that moment they pry and snoop and explore, wanting to know the answers to everything. At night they can be heard "a-whoopin' and a-hollerin'" like screech owls. Only in cold weather, when they hibernate, do raccoons lead quiet lives.

Daytime is bedtime for the raccoon. But a cloudy day may tempt it away from its tree, and it can be seen having its fun. On its black-soled feet, it likes to pad along soft river banks. It walks and runs flat-footed like a bear. Often it stops to examine a crawfish chimney before it pushes it over and thrusts in its handlike paw to feel for its prey. Or you may see it wade out to hunt frogs and turtles, or fish for oysters and mussels. These it cracks open with its strong teeth. On land it seeks out birds, insects, rats, mice, reptiles, corn, grain, and fruit.

The raccoon always washes its food. It sits on its haunches, holds the frog or other morsel in its front paws, and dips it into the water like a washerwoman to wash it again and again. When it finally munches the tidbit, it wears a dreamy and innocent look as if it had never harmed a living creature.

If captured young, the raccoon readily becomes a pet. But it must be closely watched to keep it out of mischief. One of its favorite pranks is to search its master's pockets for food. Raccoon fur, tail and all, provided the "coon-skin" caps worn by so many pioneers. Today the fur is used largely for coats and collars. Scientific name, *Procyon lotor.*

Raccoons like to live near the water so that they can bathe, go fishing, and wash their food before eating it. The one in the top picture seems to be splashing around just for fun. Below a mother raccoon is carrying her young one as a cat carries a kitten. The mothers spend a lot of time teaching the little ones proper raccoon habits.

BLACKFACE FINDS OUT ABOUT HIS NEIGHBORS

The Story of a Young Raccoon

Bright black eyes saw everything

BLACKFACE was a little raccoon, and he lived in a hollow high up in a big tree. He had four little brothers and sisters. They lived in the hollow tree, too, and so did his father and mother.

The little raccoons looked just alike. Their faces were black and their noses were sharp. They had bright black eyes that saw everything that was going on around them. All of them had fine coats of gray fur and beautiful bushy tails with black rings around them clear to the very end.

Blackface was the liveliest in the family. He was full of mischief, and he liked to romp and play better than anything in the world. He was very curious, too, and he sometimes let his curiosity get him into trouble.

"Dear, dear!" his mother would often say. "I don't know what I am going to do with you, Blackface, if you don't learn not to meddle with things you do not understand. Ask all the questions you like, but don't be nosing and touching everything that comes along." This was very hard for Blackface to learn. Every time he saw anything new he always wanted to touch it or grab it with his slender little paw to find out what it was.

Another thing that was hard for him to learn was to sleep all day. His brothers and sisters lay on the floor of the den and slept the whole day through as their mother and father did; but Blackface was too lively for that. He liked to poke his little head out at the doorway and see what was going on in the forest. Most of all, he liked to climb down the tree and play around on the ground, though he did not do this very often because his father and mother would not let him.

"I don't see why we have to sleep in the daytime, when all the other creatures are awake," he said to his father one day. "Why do we, father?"

"It is the way raccoons have always done," his father told him. "We stay in our dens in the daytime to rest and sleep. At night we go out and hunt for our food. It is much the safest way."

Blackface didn't say anything more, but he still thought it was silly to sleep in the daytime when there was so much to see and do. He made up his mind that *he* would stay awake, no matter what other raccoons did.

So one summer afternoon, when his father and mother and brothers and sisters were fast asleep, Blackface very quietly slipped out of the den. For a moment he stood on a big branch, just outside the doorway, and looked about him. Then he started down the tree.

He went down head-first, as all raccoons do, digging his little sharp claws into the bark to keep from falling. Pretty soon he reached the ground.

"Now," he thought, "I will go wherever I like, and do whatever I please. This is a lot more fun than sleeping."

He started off through the woods. He hadn't gone far, when he heard a queer noise up in a tree. *Tap—tap—tap, tap—tap—tap.* Blackface looked up. He saw a bird tapping its long bill against a tree as hard as it could.

"I wonder why he's doing that," he thought. "I'd better try to find out." So he started up the tree.

The woodpecker was getting his dinner. He was very much annoyed at being interrupted and flew away with a loud scream. Blackface went right on climbing. "Maybe he will come back," he thought. "I'll just wait, because I *must* find out why he tapped like that."

Soon the woodpecker came back and flew very near to the little raccoon. "What are you doing in my tree?" he asked angrily. "Go away this minute!"

Blackface was surprised, but he was not frightened. He answered: "I just came up here to find out why you tapped on the tree like that."

"Go away! go away! I tell you!" the woodpecker screamed louder than ever. "Go away, or I will peck you with my bill!"

"I won't go away," Blackface said stubbornly, "until I have found out what I want to know!"

The woodpecker darted at him and pecked him on the head!

"Ouch!" cried Blackface. "That hurt!"

"Of course it did!" screamed the woodpecker; "and if you don't go away I will peck you again!"

Once more it darted toward him, and this time Blackface didn't wait a second. He turned and scrambled down the tree as fast as he could go.

"Dear me!" he said when he was on the ground once more, "what a cross old bird! And I didn't find out what I wanted to know, after all."

He wandered on through the woods and soon forgot about the woodpecker, because there were so many other things to see. All kinds of creatures scampered about—up and down trees and through the grass—but none of them paid any attention to the little raccoon.

"I do wish someone would talk to me," he thought, "but everyone seems to be too busy."

So he started up the tree

Just then a black beetle came running along the path where Blackface was standing. Blackface had never seen such a queer looking thing, and without thinking he reached out to touch it. Quick as a flash, the beetle fastened its pinchers in the little raccoon's paw and pinched it sharply!

"Oh! Oh! Oh!" cried Blackface, shaking his paw. "Let go! You're hurting me! *Please* let go!"

The black beetle opened his pinchers and dropped to the ground. "There! I hope that will teach you not to meddle with me another time!" he said as he scurried away.

"Oh, dear me!" Blackface thought as he licked his paw. "Everyone in the woods seems cross. But surely if I walk far enough, I'll find *someone* who will talk to me." So he kept on walking.

At last he came to an open place where bright-colored flowers bloomed in the tall grass. "Isn't this pleasant?" Blackface thought. "I'm glad I found this place."

The sun was getting low in the sky now, and the little raccoon lay down in the grass to rest. His head was sore where the woodpecker had pecked it; his paw was sore where the beetle had pinched it; and he was tired and sleepy after his long walk.

He hadn't been lying there very long when something said *buzz—buzz—buzz,* close to his ear. Blackface turned quickly. He couldn't see anything except a little creature with wings, sitting on a flower.

The bumblebee darted at his nose

"That will teach you," said the black beetle

"Was it this little fellow who made all the racket?" he wondered. Forgetting about the woodpecker and the beetle, Blackface put out his paw to touch the little creature.

Zoom! The bumblebee darted at his nose and stung it as hard as he could!

"Oh, dear me! Oh, dear me!" cried Blackface, rubbing his nose on the ground. "That hurt! Why did you do that?"

"It's the only way I have to make you stop bothering me," said the bumblebee. "Haven't you learned not to annoy others?"

"But I only wanted to find out about you," answered Blackface, unhappily.

"Well, you found out that I can sting, didn't you?" the bumblebee said. "And now I must hurry and gather all the honey I can before it is dark."

Blackface was very uncomfortable. His head was still sore where the woodpecker had pecked him. His paw was still sore where the beetle had pinched him. His nose was still sore where the bumblebee had stung him. He wanted his mother.

Blackface shut his eyes. The sky grew dark.

"Blackface! Blackface! Blackface!" he heard. Blackface jumped up. There stood his mother! "Blackface," she said, "I have been looking everywhere for you! Where in the world have you been?"

"I have been walking through the woods to see

what I could see," Blackface said, trying to be brave.

"Well, it was very wrong of you to run away when you should have been asleep in the den. Something might have happened to you."

"Something *did* happen to me," Blackface answered quickly. And then he told his mother all about the woodpecker and the beetle and the bumblebee. And when he had finished telling her, he whimpered a little and said, "I'm awfully hungry, too, mother."

His mother did not scold him any more. She only rubbed his fur with her nose and said: "You will feel better when you have something to eat. We will go down to the stream and fish for our supper. Your father and the rest of the family are already down there."

Blackface followed his mother down to the little stream. "Hello, Blackface!" called his sister Graypaws. "Come and fish with us—we're catching crawfish."

The cool water felt very good as he waded out into it. He began to feel about on the sandy bottom of the stream with the slim fingers of his forepaws. He turned over several stones before he found what he wanted, but by and by he caught a fine crawfish.

He was so hungry that he put it to his mouth at once, but his mother called sharply: "Blackface! Don't eat your food until you have washed it! I have told you that a great many times."

"But I am so hungry, mother," the little raccoon told her. "Must I wash all the food I eat tonight?"

"Yes," answered his mother. "Raccoons always wash their food when they can, so of course you must do it too."

Blackface grumbled a little, but he dabbled the crawfish about in the water for a moment or two, and then going out on the shore, he sat down and ate it greedily.

All night long the raccoon family fished and gathered berries and dug up tender roots. At last it was time for them to go back to the hollow tree.

Blackface felt very sleepy. As he trotted along through the woods behind his mother he said:

"I thought it would be fun to go out into the forest in the daytime, but it wasn't as much fun as I thought it would be."

"No," his mother answered. "The safest place for raccoons in the daytime is inside their hollow tree."

"After this, I'm going to stay in the tree in the daytime, and sleep as you and father do," he said. "But I will go out at night, won't I? I will go out every night for the rest of my life and fish in the stream for my supper."

"Not *every* night," his mother told him. "You will fish and eat all summer, but when the cold comes, you will go to sleep in the hollow tree, and you will sleep there all winter long."

"Won't I fish at all, then?" the little raccoon asked.

"No," his mother answered, "you will only sleep. Raccoons always sleep when winter comes, so you will lie safe and snug in the den. You will not wake until the warm spring is here again."

Blackface thought about this for a little while, but he soon forgot it, for winter would not be here for a long time yet.

Safe up in the den once more he thought only about the fun he would have when he went fishing again.

All night long the raccoon family fished in the stream

The Many DIVISIONS *of the* HUMAN RACE

RACES OF MANKIND. Anyone can distinguish a blond Scandinavian from a West African Negro, a Crow Indian, a North Chinese, or a Near Easterner. Differences in appearance tell us that mankind has developed into different groups. We call these *races*. Naming and describing these racial groups accurately is not easy, and even expert scientists disagree on details.

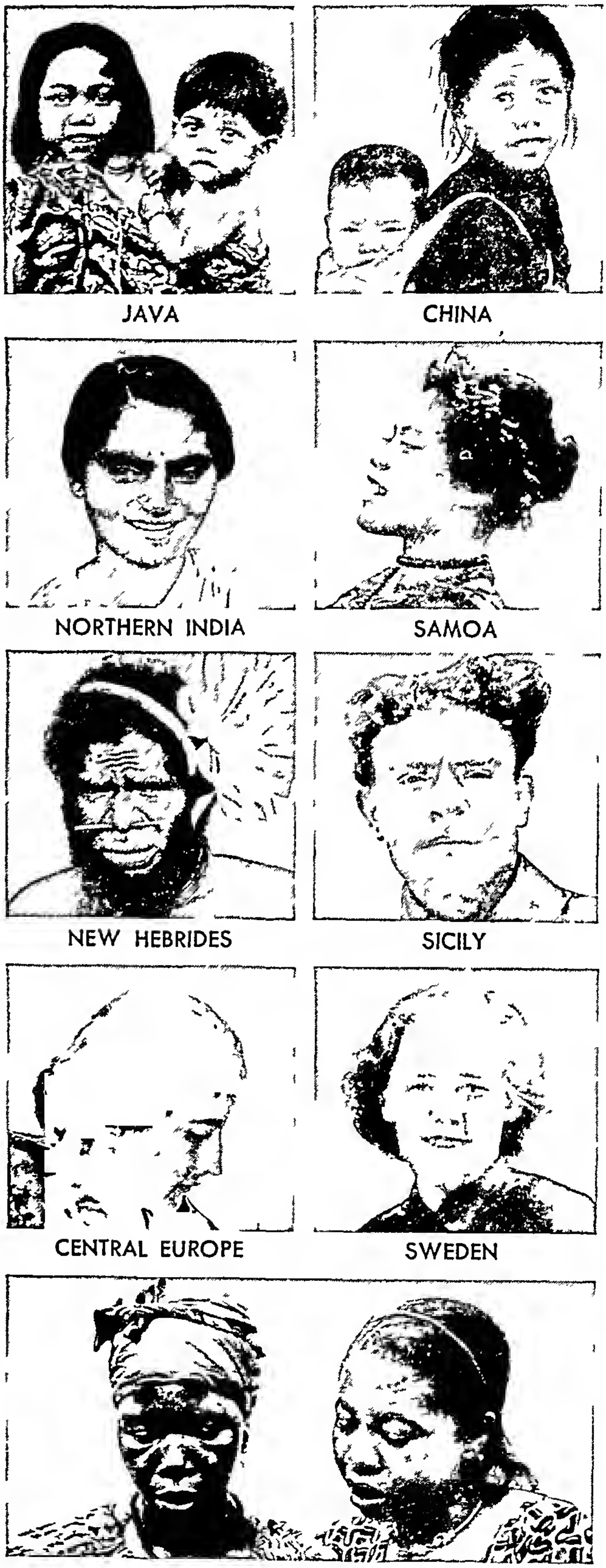
The chart on the next page shows relationships among the larger and most recognizable racial and subracial groups. Some interesting composite races, such as the Polynesian and Micronesian peoples of the Pacific, are not shown on the chart. Some peoples, such as the Australian aborigines, the Ainus of northern Japan, and the Veddoid peoples of India, Ceylon, Indo-China, and the Malay Peninsula, are difficult to classify racially and are not included in the chart. Anthropologists base their classifications solely on physical characteristics such as skin color, hair form (or texture), head shape, nasal index, lip form, hair and eye color, and face shape. The physical characteristics must be inheritable and relatively unalterable over a long period of time.

Classification by Skin Color

More than 150 years ago J. F. Blumenbach used differences in head shape and skin color to classify mankind into five races. These were Caucasian (white), Mongolian (yellow), Malayan (brown), Negro (black), and American (red). For almost a century this classification was favored by scientists, and it is still popularly used. Modern anthropologists have many objections to Blumenbach's classification. Five clearly separated colors do not exist; and skin color is somewhat influenced by environmental conditions.

Traits Other Than Skin Color

Most anthropologists limit the broad racial classifications to three: Caucasoid, Mongoloid, and Negroid. They usually select three or more physical characteristics in deciding on racial classifications. They do not disregard skin color, but they do not consider it to be the most reliable trait. The three main types of hair—wavy, straight, and woolly—are typically found in Caucasoids, Mongoloids, and Negroids respectively. Another commonly used characteristic in classifying races is head shape, the ratio of breadth to length of head. This ratio, called the *cephalic index*, is obtained by dividing maximum breadth by maximum length. A ratio of less than 75 is called *dolichocephaly* (long-headedness); 75–80 is *mesocephaly* (medium-headedness); and over 80 is *brachycephaly* (broad-headedness or short-headedness). Head shape is inheritable and is a good clue



In their facial characteristics these people are typical of those who live in the areas named. From such physical characteristics as color of hair, skin, and eyes; form, or texture, of hair; and shape of head, face, lips, and nose, anthropologists determine to what race and subrace people belong. Valid racial classifications are made only on physical distinctions.

to ancestry, but many studies have shown that it is not invariable over long periods of time.

Nasal index refers to the relationship between the width of the nose, measured between the wings, and the length of the nose. Typically, Negroids are broad-nosed, Caucasoids are narrow-nosed, and Mongoloids are medium-nosed. In general, light or dark colorations in hair, skin, and eyes go together, but different combinations occur where there has been a crossing of racial and subracial groups.

Blood Tests and Intelligence

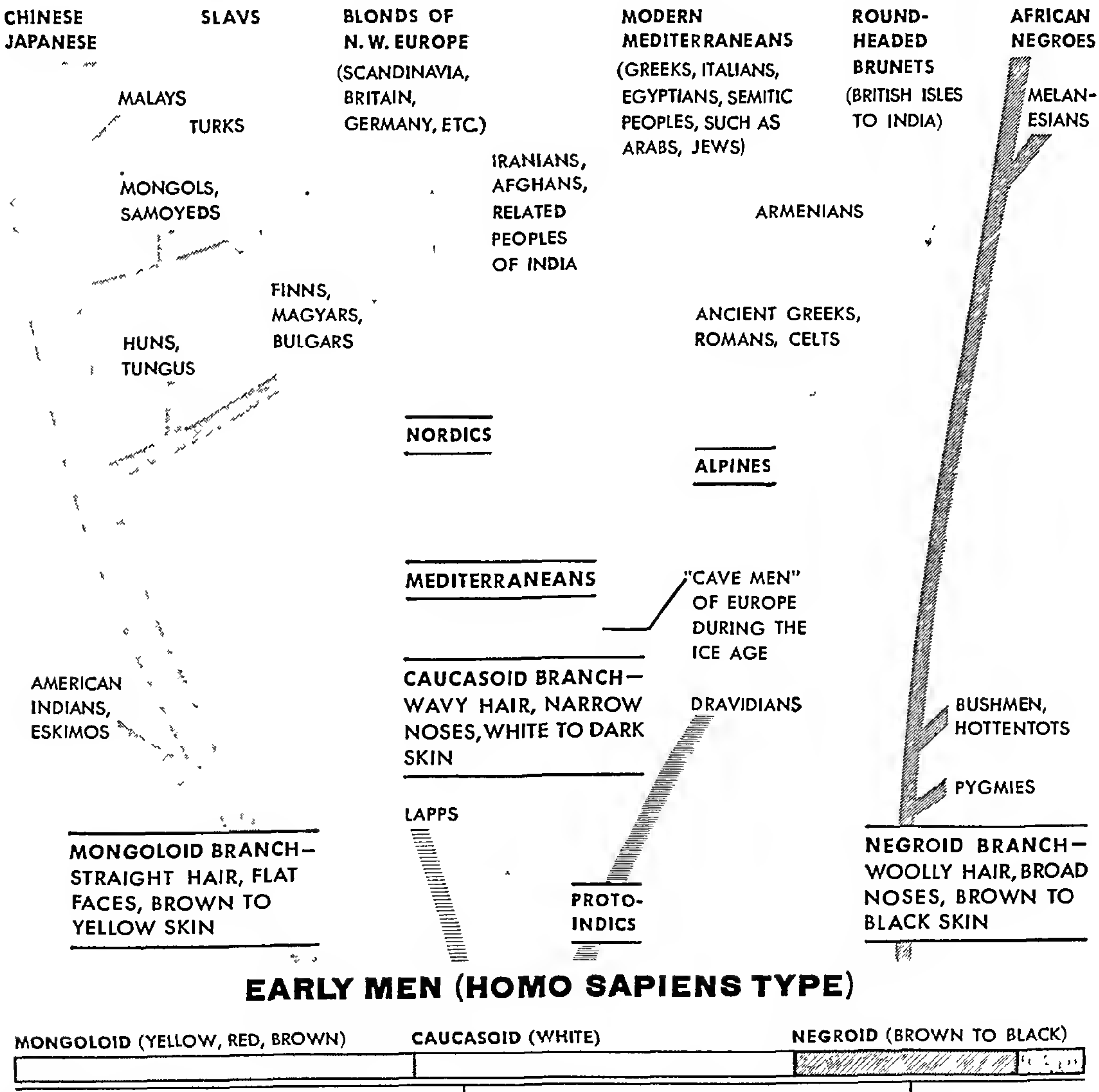
Many attempts have been made to test racial inheritance by blood type. Each person inherits a particular type of blood and transmits it to his children, in accordance with Mendel's law of heredity (*see* Blood). However, no definite correlation with race has been proved. Every type is found in every population, whether Caucasoid, Mongoloid, or Negroid. Even members of the same family, the so-called "blood relatives," are likely to differ in blood type.

Claims that intelligence and personality traits vary with race are unfounded. Most of these claims were intended to stimulate national pride or to arouse prejudice; and none of them is justified by scientific evidence. Apparent racial differences are produced by environmental influences and social conditions. Basic intelligence is the same in all races.

Subdivisions of the Three Major Races

Anthropologists have worked out various subdivisions of the main races. The number of subdivisions, often called *subraces,* listed under any race depends on the number of physical characteristics used and the fineness of the distinctions made. The three principal subraces of Caucasoids are Nordic, Alpine, and

HOW THE CHIEF RACES ARE RELATED TO ONE ANOTHER



This chart shows how the various races have developed since prehistoric times. Estimated sizes of the chief races are given in the bar graph at the bottom. The last segment shows the relative size of the composite races (not included on the chart).

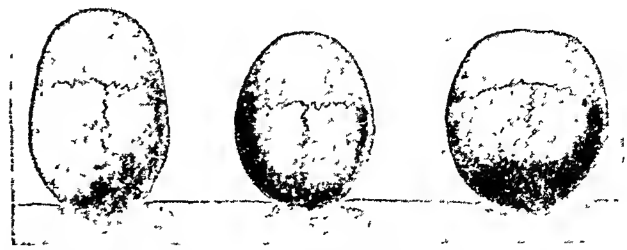
Mediterranean. Today all white peoples are varying mixtures of these three types. The greatest degree of Nordicism is found in the Scandinavian countries and northern Germany. The most Alpinism is found among the Slavic peoples and among the predominant types in Switzerland, southern Germany, and central France. The inhabitants of Spain, Portugal, southern France, southern Italy, Greece, and some parts of North Africa and the Near East are most typical of the Mediterranean subrace.

The subdivisions of the Negroid race are many. They include the Forest Negroes of western and central Africa and of South Africa; the Nilotic Negroes of the upper course of the White Nile and of the Blue Nile; the Oceanic Negroes of Melanesia (Fiji Islands, Solomon Islands, New Guinea, and nearby areas); the Negritos of the Congo forest area, Andaman Islands, Malay Peninsula, and the Philippines; and the Bushmen-Hottentot peoples of South Africa. Subdivisions of the Mongoloid race include the Classic Mongoloids (North China, Tibet, and nearby areas); the Malaysians (Malay Peninsula, East Indies, and nearby areas); and the American Indians.

Racial Tensions

One of the most interesting facts of history has been the world-wide expansion of the white race during the four centuries between 1500 and 1900. At the end of the 15th century the white race was confined to about 2 million square miles of Europe. The remaining 51 million square miles of the earth's land area (excluding the polar regions) was held by people of other races. At the end of the 19th century, the area predominantly populated by whites was 22 million square miles, as against 31 million square miles for the other races. All but 6 million of this 31 million square miles was under white political control. The white race, comprising about one third of the world population, controls nine tenths of its area (*see* Population).

THE THREE TYPES OF HEADS



The shape of the skull helps in distinguishing races. The three main types are (left to right) long headed (dolichocephalic), medium headed (mesocephalic), and short headed (brachycephalic).

Negroid and Mongoloid races under white domination have shown constant unrest. World War I aroused doubt that the white peoples could continue to maintain governments and lasting peace in Asia and Africa. For a time during World War II, Japan seemed to be gaining control of Asia. This control was broken when Japan surrendered. Later, independence was given to the East Indies, Burma, Ceylon, India, and the new nation of Pakistan.

Africa has long been a troubled continent. In the 1950's some self-government was extended to the Gold Coast, a West African British colony. The Negro peoples of the Belgian Congo are underprivileged, but some steps have been taken by the government to improve social and educational conditions.

After World War II there was much unrest in East Africa, especially in Kenya. The greatest racial tension in the modern world exists in South Africa. This has been created by the *apartheid* ("separateness") policy, under which the races are to be strictly segregated. (*See also* Africa; East Africa; South Africa, Union of.)

Nationalistic sentiments among the non-white peoples of the world have greatly increased since the 1930's. No one can accurately predict the outcome of the current changes in world race relationships.

REFERENCE-OUTLINE FOR STUDY OF RACES OF MANKIND

ANTHROPOLOGY AND ETHNOLOGY A-264

I. **Classification of races:** by skin color R-21, S-193; by hair R-21, H-243; by head shape R-21, picture R-23

II. **Classification of groups:** by language L-98

THE CAUCASOID RACE

I. **North Mediterranean groups (modern Mediterranean, Nordic or Teutonic, and Alpine stocks)** R-23, diagram R-22

- A. **Teutonic** E-431, T-76: Germans G-91, 96, E-431; English E-348, E-358; Scandinavians S-55, N-294 (Danes D-70, Icelanders I-10*b*; Norwegians N-302, Swedes S-461); Dutch N-114
- B. **Romanic** R-180: French F-258; Italians I-265; Portuguese P-378; Rumanians R-253; Spaniards S-313-14
- C. **Slavic** S-198, E-431, C-328: Czechs, or Bohemians, and Slovaks C-535, B-221; Poles P-342; Russians R-262; Ruthenians U-233; Serbs S-102; Slovenes and Croats Y-346
- D. **Hellenic:** Greeks G-190-1, C-327
- E. **Illyric:** Albanians A-138; Bulgarians B-349
- F. **Celtic** C-163, E-348, E-357: Bretons B-327; Irish I-227; Scots S-63; Welsh W-3
- G. **Lettic:** Letts L-135; Lithuanians L-276
- H. **Indo-Iranian:** Afghans A-31; Armenians A-374; Kurds K-68; Iranians P-155, I-222, C-327; Gypsies G-235; Hindus H-357, I-57
- I. **Caucasian:** Circassians and Georgians C-156
- J. **Basques of the Pyrenees** S-314, F-259

II. **South Mediterranean groups (Hamito-Semitic families)** A-48: Arabs A-284, A-415; Ethiopians E-401-2; Jews J-351; Berbers M-389; Egyptians E-272, C-326 (Copts E-273); East Africans (Gallas, Somalis, Masai) E-402, A-48, E-198

THE NEGROID RACE

I. **African Negroes** R-23

- A. **North African** (Sudanese) A-48: Ashantis A-36
- B. **South African** (Bantu, a collective name including Zulu, Mashona, Matabele, Swazi, Bechuana,

Basuto, Xosa, Fingo, and many others) S-242, 244, A-48, 52-3: Mozambique M-442
C. East African (Swahili and Kikuyu) E-198

II. Pygmies P-444
A. Negrillos (African) P-444, A-48, picture A-40
B. Negritos (Asiatic) P-444: Philippine Islands P-194-5; Malaya (Semang) M-59

III. Oceanic Negroes: Papuans N-142, E-204; Melanesians P-4, E-204, F-66, pictures P-3

THE MONGOLOID RACE

I. Northern Mongolic family
A. Mongolo-Tatar branch: Cossacks C-489; Kalmucks M-346; Kirghiz A-414; Manchus C-279, M-75; Tatars T-23; Mongols M-342-4, M-346; Turkomen T-214; Turks (Ottomans) T-216-18
B. Finno-Ugrian branch
1. Finnish: Estonians E-400; Finns F-71; Lapps L-102; Samoyeds (Fact-Index)
2. Ugric: Magyars H-448; Ostiaks R-262
C. Japanese-Korean branch: Japanese J-298; Koreans K-64*a*

II. Southern Mongolic family
A. Tibetans T-127, I-57
B. Indo-Chinese I-121: Annamese I-123; Burmese B-359; Thais (Siamese) S-169; Khmers I-123
C. Chinese C-260, F-242*a*

III. East Indian group E-204: Malays M-58, picture B-255; Dyaks B-254; Javanese J-328; Sumatrans S-449, picture E-208; Sundanese J-328

IV. Philippine group P-194, pictures P-196

V. Prehistoric American Indians I-108*e*: Cliff Dwellers C-347; Mound Builders M-438

VI. North American Indians I-89: culture areas, maps I-91, 106*f*; principal tribes, table I-107-8; Caribou Hunters I-94; Eastern Woodland I-92, 99; Northwest Fishermen I-94, 106*c*; Plains I-92, 103; Seed Gatherers I-93, 106*a*: Southwest I-93, 104*c*; Eskimos E-396, I-94; Aztecs in Mexico A-542, I-110

VII. Central American Indians C-172-3, pictures C-174, G-122*a*: Mayas M-143*a*, I-110

VIII. South American Indians S-261: Incas I-50, I-110, S-263; Aymarás S-263; Chunchos, picture P-161; Tupis, Arawaks, Caribs, Guaranis S-262; Araucanians C-255; Yahgans C-254, S-262; Onas S-262, picture S-259; Patagonians P-96, S-263

RACES OF MIXED CHARACTERISTICS

I. Dravidian group I-56-7: Veddahs and Sinhalese C-180

II. Madagascar group: Malagasy M-20

III. Polynesian group P-4, pictures P-3: Hawaiians H-288*a*, pictures H-288*b*, 289; Maoris N-228, pictures N-228*a*; Samoans S-35, pictures P-12

IV. Micronesian group P-4: Gilbert Islanders, picture P-3

V. Hottentots and Bushmen A-48, S-242, picture E-454

VI. Ainus of northern Japan J-298, picture J-298

VII. Australian aborigines (blackfellows) A-480

BIBLIOGRAPHY FOR RACES OF MANKIND

Books for Younger Readers

Benedict, R. F. In Henry's Backyard; the Races of Mankind (Schuman, 1948).
Eberle, Irmengarde. Big Family of Peoples (Crowell, 1952).
Evans, E. K. All about Us (Capitol, 1947).
Evans, E. K. People Are Important (Capitol, 1951).
Linton, Ralph and A. S. Man's Way from Cave to Skyscraper (Harper, 1947).
Lucas, J. M. Man's First Million Years (Harcourt, 1941).
Masani, M. R. Growing Human Family (Oxford, 1951).
UNESCO. What Is Race: Evidence from Scientists (Columbia Univ. Press, 1952).

Books for Advanced Students and Teachers

Ashley-Montagu, M. F. Man's Most Dangerous Myth; the Fallacy of Race (Harper, 1952).
Ashley-Montagu, M. F. Statement on Race (Schuman, 1951).
Baruch, D. W. Glass House of Prejudice (Morrow, 1946).
Benedict, R. F. Race: Science and Politics (Viking, 1945).
Brown, F. J. and Roucek, J. S. One America (Prentice-Hall, 1952).
Brown, I. C. Race Relations in a Democracy (Harper, 1949).
Count, E. W., ed. This Is Race (Schuman, 1950).
Hammond, C. S. & Co. March of Civilization in Maps and Pictures (Hammond, 1950).
Kluckhohn, Clyde. Mirror for Man (McGraw, 1949).
Kroeber, A. L. Anthropology (Harcourt, 1948).
McWilliams, Carey. Brothers under the Skin (Little, 1951).
Powdermaker, Hortense. Probing Our Prejudices (Harper, 1944).

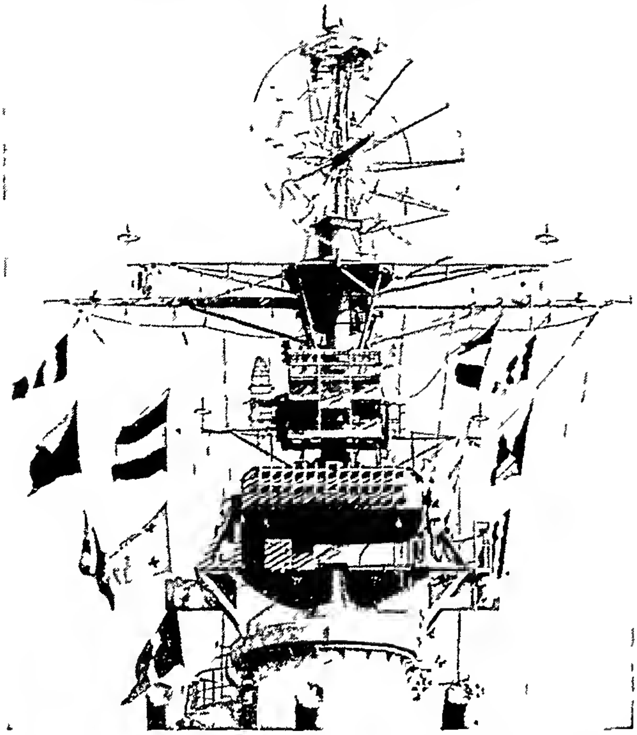
RACINE (*rá-sēn'*), **JEAN BAPTISTE** (1639–1699). Most French critics consider Racine the greatest dramatic poet of France. It may be disputed, however, whether he ranks above Corneille, who first shaped French tragedy, or Molière, the great comic dramatist. Unlike those of Corneille, Racine's heroes and heroines are well endowed with human frailties, and so his plays seem more lifelike than the austere dramas of Corneille. Racine allowed the emotions of his characters, as much as their reason, to govern their actions. To some extent he freed French drama of the unnaturalness which came from following rigid rules, letting his own taste and the nature of the story determine the form of his plays.

Racine was born at La Ferté-Milon, northeast of Paris. His parents died when he was young and his grandfather educated him at the college of Beauvais and at the Jansenist institution of Port-Royal. At about 25 he made the acquaintance of the poets La Fontaine, Boileau, and Molière. His first play, which was staged by Molière's acting company in 1664, benefited from the criticism of these friends. His other great plays followed in close order, and in 1673 he was admitted to the French Academy.

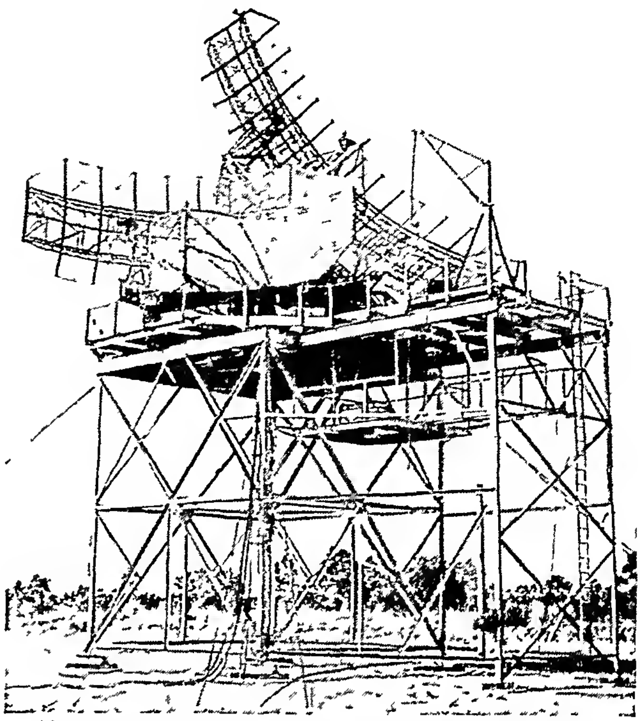
Though reared a Jansenist, Racine had turned away from the movement upon becoming a playwright. In 1677, however, angered by hostile criticism, he deserted the theater and made his peace with the Jansenists. In the same year he married Catherine de Romanet, who bore him two sons and five daughters. The poet died in Paris and was buried at Port-Royal.

Racine's principal works are: 'La Thébaïde' (1664); 'Alexandre le Grand' (1665); 'Andromaque' (1667); 'Les Plaideurs' (1668), his only comedy; 'Bérénice' (1670); 'Bajazet' (1672); 'Mithridate' (1673); 'Iphigénie' (1674); 'Phèdre' (1677).

How RADAR "SEES" *Objects and* MEASURES *Distances*



This circular radar antenna is fixed to the highest point of the superstructure of the United States cruiser 'Pasadena'. It can rotate completely around its supporting mast.



Air Force men are installing a pair of huge radar antennas on this towerlike structure. Radar impulses from the antennas will sweep the sky for friendly or enemy planes.

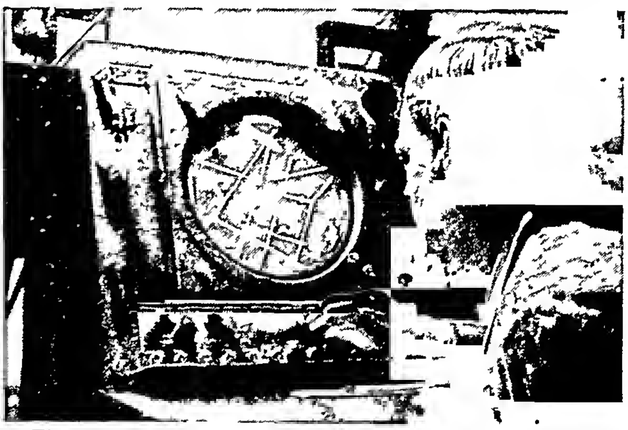
RADAR. Today a sea captain can move a ship safely in a crowded harbor even in dense fog. An airplane pilot can land his plane safely through a thick overcast. They are able to do so, even though they cannot see more than a few feet ahead, because an electronic device called *radar* "sees" for them.

A radar "eye" can pierce fog, storm, or black night as far as the horizon. Within its range it can show an observer ships, planes, storm clouds, small islands, coast lines, and prominent landmarks. It also measures the distance to these objects. For military use, radar can determine gun ranges and bearings and control guided missiles. One type of radar can identify friendly and enemy ships and airplanes. Radar can even tell the distance to the moon.

What Is Radar?

Radar is an application of the special properties of *ultra short*, or *micro*, electromagnetic waves. Shortly after the first World War, radio engineers learned that these waves act differently from longer waves (*see* Radio). The waves bounce back from solid objects in their path, just as waves of sound bounce back when they hit a wall and cause an echo. After several years of work, scientists learned to use this "echo" action of microwaves for detection and measurement. They coined the name "radar" from the first letters of the words "radio direction and ranging."

The diagram at the top of the next page shows a radar set sending waves and receiving echoes. The same radar set with its antenna both transmits and receives. Wave bursts, or *pulses*, are spaced to give



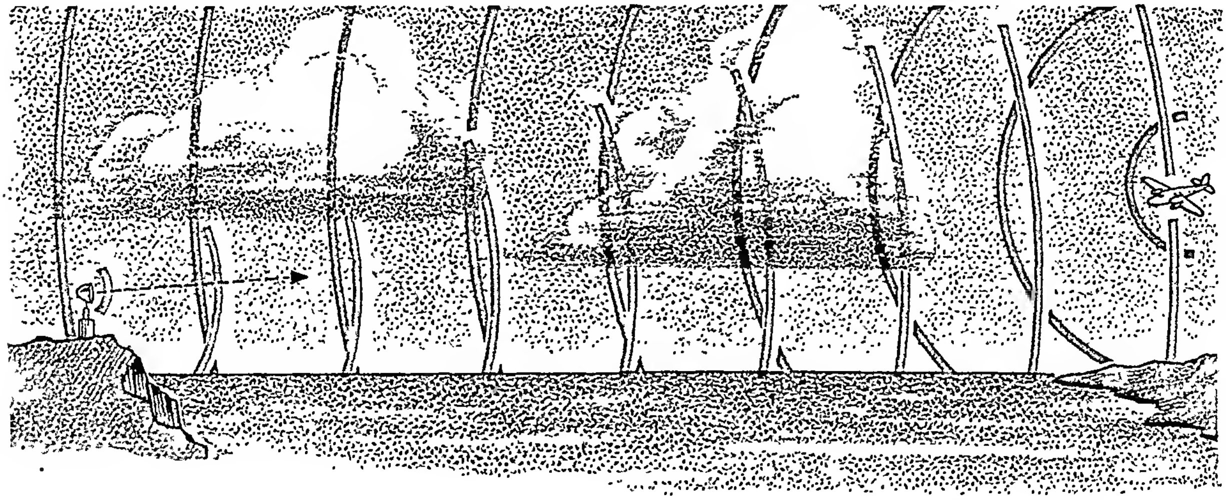
The streaks of light on this radarscope are planes circling over an airport. With radar to guide them, ground men can radio landing instructions to the pilots overhead.

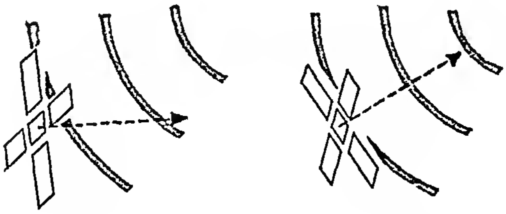
time for receiving an echo from one pulse before the next pulse goes out. For example, a set may be designed for a range of 93 miles. It sends out pulses at intervals of 1/1000th of a second, and these travel at a speed of 186,000 miles a second. In 1/1000th of a second a pulse has time to travel to the edge of the search area, strike an object, and return as an echo—a round trip of 186 miles—before the next pulse of radio energy goes out.

Inside a Radar Set

The set does not actually send single waves in this way. Single waves would not give strong enough echoes. Each pulse consists of a group or train of waves, and each wave in the pulse must occur at fre-

A RADAR SEARCH BEAM SPOTS A PLANE





To search a region, a transmitter sends bursts of microwaves (orange). Waves which hit a plane are reflected as "echoes" (blue). The time taken by the echo to return tells how far away the plane is. The direction of the plane is found with a four-part antenna, shown in the diagrams at the left. If the antenna axis is not "on" the plane, the parts receive the echo at less than full strength (first diagram). The maximum echoes appear when the axis is directly on the plane (second diagram).

quencies, as high as 10,000 megacycles a second. (A megacycle is a million cycles. The corresponding wave length is 300 meters, or 984 feet.) Radar achieves these high frequencies by means of a *magnetron* tube. This tube whirls an electric impulse in a magnetic field until it is strong enough for transmission. Then the radar antenna shoots the impulse out.

When a train of waves echoes back, the antenna transmits the pulse to an *oscilloscope*. The oscilloscope transforms the pulse into a beam of light which an observer can see. (Both the magnetron and the oscilloscope action are explained in the article Electrons.)

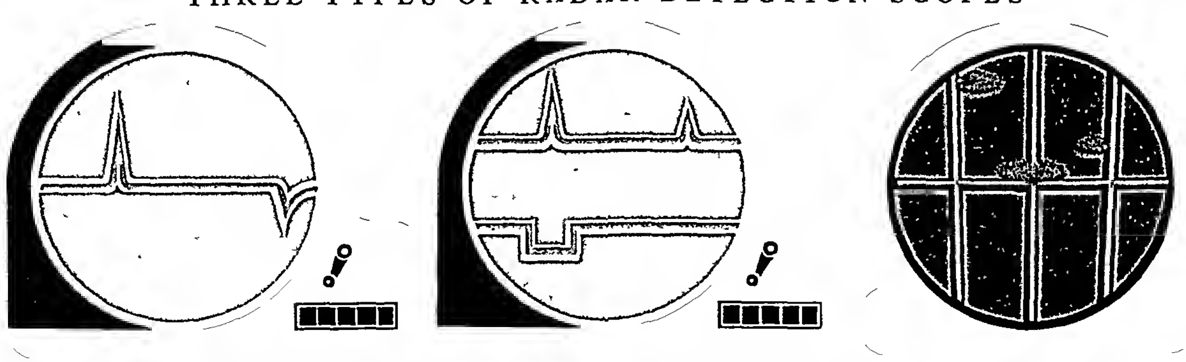
Kinds of Radar

In one type of radar, called an A-scope, an electron beam sweeps across the oscilloscope screen once during each interval between pulses. The sweep forms a line of light called a *time base*. The length of the time base corresponds with the range of the radar set. If the pulses go out 1/1000th of a second apart, the time base corresponds to a range of 93 miles.

The repeated sweeps of the electron beam maintain a straight line across the screen. An echo, however, causes the line to spurt upward in a narrow peak called a *pip*. This occurs at a point along the line corresponding to the distance (range) of the reflecting object. In our example, an object 31 miles away would cause a pip to appear one third of the way along the line.

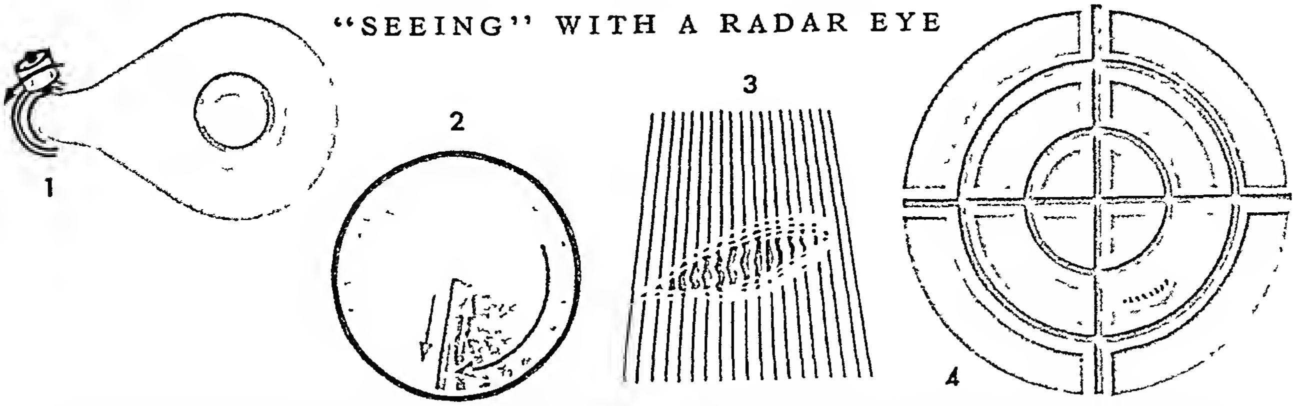
Radar can also show a flat picture of the area around a ship or plane. The antenna rotates con-

THREE TYPES OF RADAR DETECTION SCOPES

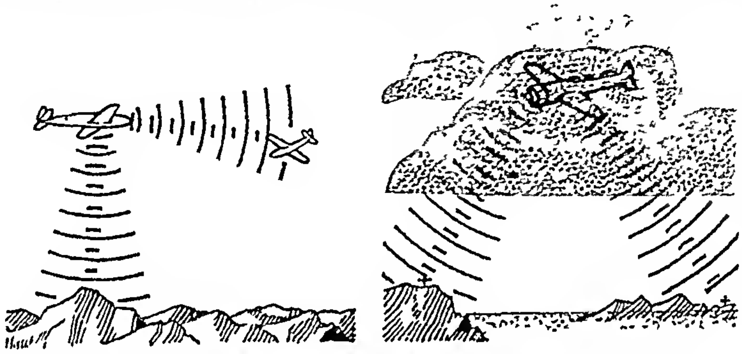


The A-scope (left) shows one pip rising from the time base. Turning the crank brings the end of the line up to the pip so that the lower projection lines up with the pip. The dial then shows the distance to the object. The similar IFF scope (center) is used for identifying friendly craft. Here two pips on the upper line indicate two planes. The matching signal on the lower line shows that the first plane is friendly. The second may be an enemy. The B-scope (right) gives a flat, maplike picture of objects in a small area. Up-and-down lines give the bearing of a pip. With a range knob the operator moves the picture until the pip is aligned with the horizontal range line. Then he reads the distance to the object from the range knob.

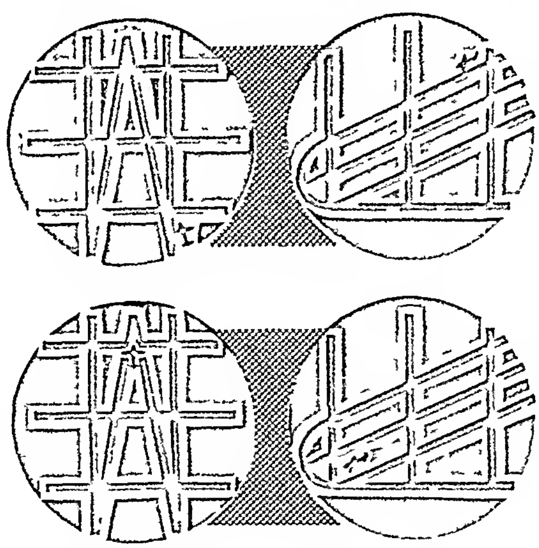
"SEEING" WITH A RADAR EYE



In a "seeing" radar, a beam of outgoing waves sweeps many times a second over the field of search, and an oscilloscope follows the search as shown above. A "time base" line is projected outward from the center of the oscilloscope, as described in the text. Then a rotating magnetic field around the oscilloscope (1) draws the beam rapidly around the screen (2), rotating the beam in time with the turning antenna. Whenever the outgoing waves are reflected back by an object, they cause bright spots on the screen (shown enlarged in 3). These spots form a silhouette of the object (4).



A radar "eye" can show dangerous objects ahead, and waves reflected from below can tell height (left). If an aviator needs to learn his location, a radar call (right) brings answers from automatic radar beacons. The echo tells the distance from each beacon. The aviator finds a point on his map at the right distance from the beacons, and that is his location.



RADAR AID FOR LANDING

With the twin 'scopes shown above, an operator on the ground can bring planes to safe landings in storm or fog. In each pair of 'scopes, the left one shows the field as seen from above, with a V for the zone of safe approach. The right one shows a side view, with "slots" for correct descent. In the upper pair, an approaching plane is outside the V and the slots. The ground operator advises the pilot, and in the lower 'scopes, the pilot is landing correctly. When he reaches the cross line at the end, the operator tells him to level off, and the plane lands safely.

stantly as it sends out its search beam. The time-base line on the oscilloscope sweeps around the screen in time with the antenna, as a sweep second hand on the face of a watch. It leaves in its wake a constantly renewed picture of solid objects that meet the search beam. This type of scope is called a PPI—Plan Position Indicator. The PPI is much used on planes and ships to give a clear picture of surrounding objects. It can be used to indicate directions (bearings) of objects, but to measure distances accurately an A-scope or *B-scope* is needed.

The B-scope forms an enlarged image of a PPI picture and projects this on a screen which is bisected by a horizontal range line. The operator can select any sector of the PPI to enlarge. With the help of the range line he can read the distance to any object in that sector extremely accurately. The B-scope also indicates the bearing of the object.

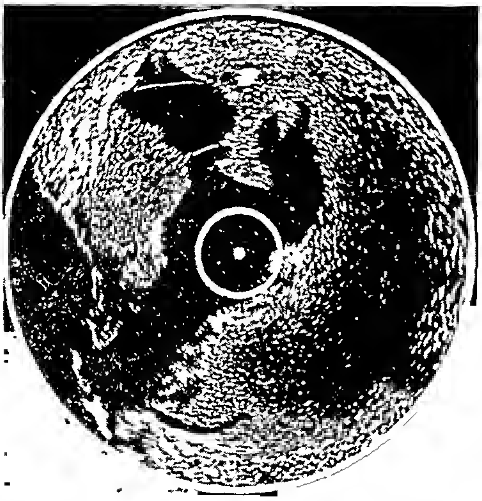
Another device on certain types of radar indicates the altitude of an airplane whose image is on an A-scope. This device shows how much the antenna has been tilted upward (or downward) to find the plane. This figure is the plane's *angle of elevation.* From it and from the range of the plane, the altitude can be readily calculated.

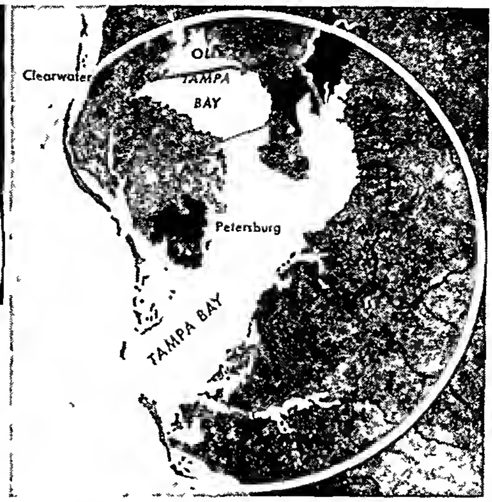
War Uses

The second World War brought intensive development and use of radar. The British credit radar with enabling them to beat off the heavy German air assault in 1940–41. Thereafter radar helped the Allies to carry the air war to their enemies at night and in all kinds of weather. At sea radar helped ships to maintain formation at night and in fog or storm. It enabled them to fire guns or drop bombs accurately on enemy ships and land installations which they could not see. Radar was sensitive enough to detect enemy submarines when only their periscopes projected above water.

Friendly ships and planes could identify one another by means of equipment called IFF—Identification, Friend or Foe. Each craft carried a device called a *transponder,* which replied automatically in code to signals from other friendly craft. Transponders were also used on the ground as radio beacons.

A RADAR-EYE VIEW OF A CITY AND SURROUNDINGS





In the picture at the left is a radar view of Tampa Bay, Fla., obtained by the method shown on the preceding page. The small central circle marks the overhead position of the plane. Accuracy and completeness of detail can be judged by comparing the radar view with the map at the right.

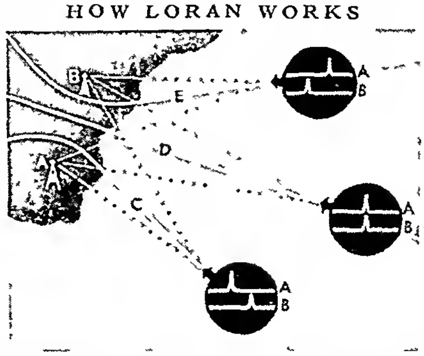
Another radar device helped airplanes make "blind" landings, as shown in the pictures on a preceding page. This was called GCA—Ground Control of Approach—and the device was usually installed on a truck. A team of radar and radio operators worked together to "talk" the pilot safely down to the runway. After the war, commercial airlines gradually adopted GCA for helping planes land through thick overcasts.

Early radar equipment was bulky and cumbersome, but in 1944 a simple radar set was made small enough to fit in the nose of a shell or bomb. This was the VT (Variable Time) radio proximity fuse, based on a different principle than the larger unit. As the shell neared the target, a radar echo set off the fuse at the appropriate distance (*see* Artillery). The small unit suggested many peacetime uses.

Navigation, Weather Study, and Space Exploration

One of the most useful radar devices to come out of the second World War is *loran* (so called from the first letters of the words "long range navigation"). With loran a ship or airplane navigator can quickly find his position in any kind of weather. The method uses signals from land stations which work in pairs. Each station of the pair sends signals at regular intervals. The signals go out in waves and crisscross in space, just like ripples in a pond when two stones are dropped near each other. The intersections occur along definite points. These points form lines which can be traced on a navigation chart.

HOW LORAN WORKS



Two stations, A and B, send out radio waves which intersect along lines such as C, D, and E. Each line corresponds to a certain difference in the time when signals from A and B will reach a ship. If they come at the same time, for example, the ship is somewhere along line D. A radar oscilloscope can detect the time differences and identify the lines, which can be found on special loran charts. These time differences are suggested by the pips in the circular sketches.

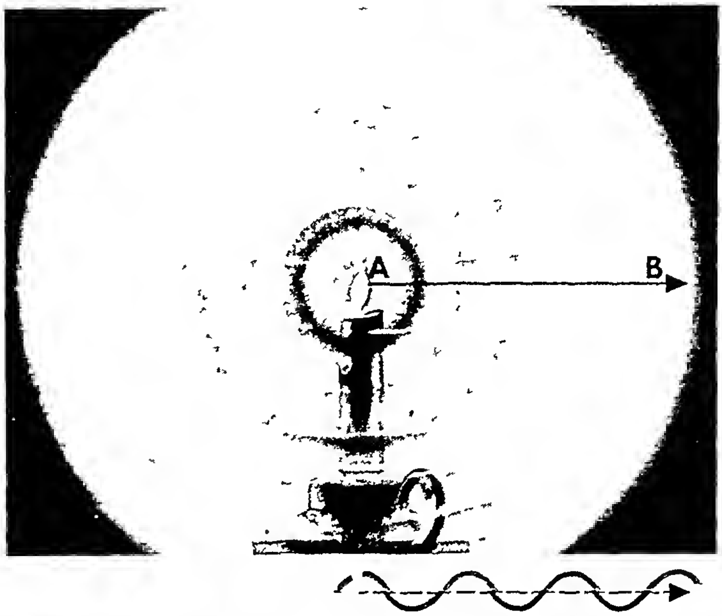
The loran receiver on a ship or plane has an oscilloscope similar to an A-scope to pick up the signals from the two stations. The pip from each station shows on a separate time base line on a screen. The oscilloscope measures the difference between the instants of time when the pips are received. This time difference corresponds to one of the lines on the chart. After the navigator has found himself on a line from one pair of stations, he locates himself on a line determined by signals from another pair. The point where the two lines cross on the chart is the position of his craft.

Shoran (from "short range navigation") is especially useful in surveying. A plane flies over the area to be surveyed and transmits radar signals to two stations. The time taken for the signals to return establishes the plane's distance from the stations. The pilot photographs the area and at the same time photographs the information shown on his radar scopes. Back on the ground, map makers identify the photographs of the area from the locational information on the accompanying radar photographs.

Radar waves can penetrate the ionosphere and travel from the earth into outer space. This suggests startling possibilities in learning more about worlds beyond our own. In 1946, United States Army experts sent radar impulses to the moon and received unmistakable echoes. Scientists use radar to study intensity of ionization of meteor trails and to learn how radio frequencies are affected by meteor showers. Radar helps predict weather conditions. A radar plane can circle a region and report the location and intensity of thunderclouds. Radar can follow a hurricane and find its regions of highest and lowest pressures.

Many scientists helped develop radar. In the United States A. Hoyt Taylor and Leo C. Young published research data in 1922. Pioneer work on ionosphere reflections was done by a British scientist, E. V. Appleton, and two Americans, M. A. Tuve and Gregory Breit. In 1925 Louis A. Gebhard built the first pulse transmitter. Sir Robert Watson-Watt led British research in the 1930's. In the second World War, the Radiation Laboratory at the Massachusetts Institute of Technology sponsored large-scale research.

RADIATIONS
That Carry Energy Across Space



Radiations spread out from sources such as lighted candles as expanding spheres of electromagnetic pulses called *waves.* Alternate spheres have reversed electric and magnetic character. Along any one line of travel (AB) this can be shown as crests and troughs in a wavy line.

RADIATION. One reason we remain alive is because we are constantly bathed by many kinds of *radiations.* These are forms of energy which move across space from sources outside ourselves. The earth and everything on it depend for heat upon energy radiated from the sun. Sunlight and light from other sources provide us with visible images. Still other radiations give us radio, television, ultraviolet, and X rays.

Some radiations, such as light from distant galaxies, may travel for thousands or millions of years across the vast emptiness of outer space. Others, such as heat from a radiator, may travel only across a room. Different kinds also affect us differently. Radiant heat and ultraviolet may be detected by our skin. We see light with our eyes. X rays pass through us without our feeling anything, but the passage can be detected by special instruments. The same is true of radio and television waves.

The different radiations are forms of energy because they can "make something happen." They are called radiations because they travel outward, or "radiate," without needing energy to drive them, other than that given them at their sources.

Common Properties of All Radiations

Although these radiations produce quite different effects, they are alike in several ways.

They all travel at the same speed across empty space—that is, in a vacuum. Since this speed was first measured for light, it is usually called the *speed of light* (*see* Light).

All radiations travel outward from their sources as pulses of energy called *waves.* The waves really consist of electric and magnetic fields operating crosswise to each other and reversing directions with each pulse. Two pulses with their reversals bring the fields to their starting conditions, and the sequence constitutes a wave. In any one direction, all this can be indicated by a wavy line.

When traveling across space, the different kinds of radiation differ only in *frequency*—that is, rate of vibration or number of waves a second—and in *wave length,* or distance from one crest to the next along a line used for a wave. A table on the next page gives frequencies and wave lengths for the different types, when moving through empty space.

Since the radiations all travel at the same speed in empty space, the wave length multiplied by the frequency must always give the same result—the speed of light. This fact can be expressed by simple formulas, using f for frequency, w for wave length, and l for the speed of light:

$$fw = l \qquad f = \frac{l}{w} \qquad w = \frac{l}{f}$$

Physicists commonly use the Greek letter λ (*lambda*) for w, and c for the speed of light. With these letters the formulas are:

$$f\lambda = c \qquad f = \frac{c}{\lambda} \qquad \lambda = \frac{c}{f}$$

The speed is reduced by various amounts whenever radiations travel through matter, even matter as thin as air. This can be stated in formulas by using the reduced speed instead of c. The reduction occurs in wave lengths. Frequency always remains the same.

The Electromagnetic Nature of Radiation

The electromagnetic character of all radiation was first suspected in 1873, when James Clerk Maxwell predicted that waves like those of light, except vastly longer, could be created by electromagnetic force. In 1888 Heinrich Hertz proved this. His discovery was developed into radio, television, and radar.

This theory also suggested that light must be sent forth by electromagnetic forces acting somehow

KIND OF RADIATION	WAVE LENGTH			FREQUENCY		
	CENTIMETERS	METERS		KILOCYCLES	MEGACYCLES	F. C. C. CLASSIFICATION
RADIO		10,000		3×10		Very low
Transoceanic telegraphy		2,000		3×100		Low
Standard broadcast		100		$3\times1{,}000$		Medium
Television	100	1		$3\times10{,}000$		High
	10			$3\times100{,}000$	3×100	Very high
Microwave characteristics	1				$3\times1{,}000$	Ultra high
					$3\times10{,}000$	Super high
					($=10^{10}$ cycles)	Extremely high
		MICRONS		CYCLES (by powers of 10)		
	$0.1=10^{-1}$	1000		3×10^{11}		
	10^{-2}	100		3×10^{12}		
INFRARED	10^{-3}	10	ANGSTROMS	3×10^{13}		
VISIBLE LIGHT	10^{-4}	1	10,000	3×10^{14}		
Ultraviolet	10^{-5}		1,000	3×10^{15}		
	10^{-6}		100	3×10^{16}		
X RAYS	10^{-7}		10	3×10^{17}		
	10^{-8}		1	3×10^{18}		
Gamma rays	10^{-9}		·	3×10^{19}		
	10^{-10}			3×10^{20}		
	10^{-11}			3×10^{21}		

DIFFERENT RADIATIONS IN THE ELECTROMAGNETIC SPECTRUM

The classification of radio frequencies in this table is the one used by the Federal Communications Commission. Overlaps between radiations are explained in the article on Energy. Wave lengths are stated in various commonly used units. The micron, for example, is named from *micro*, meaning (in measurements) "one millionth." It is a millionth of the fundamental unit, the meter. *Kilo* means "thousand"; and *mega*, "million." Exponents are used for numbers with many zeros. For example, $3\text{x}10^{11}=300{,}000{,}000{,}000$. Decimal fractions are shown with negative exponents, thus: $.001=10^{-3}$; $.0001=10^{-4}$; and so on.

in the particles of matter. Between 1912 and 1925, physicists learned how this happens, not only for light, but also for infrared, ultraviolet, and X rays.

How Matter Gives Rise to Radiation

Matter sends out and responds to electromagnetic radiations because the atoms of matter contain electrified particles. Each atom has a nucleus containing one or more positively charged particles called *protons*. Around each nucleus is an array of negatively charged electrons, exactly equal in number to the protons (*see* Atoms; Matter).

The positive charge or charges on the nucleus attract the electrons by electrostatic force (the law of electricity that "unlike charges attract"). Each electron, however, has a certain natural amount of energy which keeps the electron flying, like a stone whirled at the end of a string, in certain paths around the nucleus. Electrostatic attraction from the nucleus acts to hold the electron like the string tied on the stone. Energy from outside the atom can enter to disturb the relation between "whirl" and "string." Such disturbances, and the adjustments the atom makes to compensate for them, provide the ways in which the atom enters into various physical and chemical reactions.

Scattering, Reflection, and Absorption

Disturbances of electrons occur because all radiations carry both an electric and a magnetic field; but the electric field is usually far more effective than the magnetic field in causing interactions with electrons. Such interactions can occur in either of two ways.

In *scattering* or *reflection* of radiation, as with light, the interaction occurs when the electric field carried by a portion of a passing wave "bumps" the negative charge on an electron, and the bump tends to drive the electron from its normal relations with its atom. The forces holding the electron are strong enough, however, to make it simply "bump back," without itself being particularly disturbed.

This bouncing back forces the portion of the wave to change direction in some way; and what happens on the whole depends upon how the changes average out for the portions of waves which strike the billions of electrons involved in any sizable interaction. The results always are mixed; but usually one or more will predominate over the other. The predominant effect may be scattering, reflection, or refraction followed by transmission through the matter.

The second kind of interaction occurs when a portion of the passing wave has exactly the right amount (or choice of amounts) of energy to succeed in disturbing the electron's relations to its atom or to a molecule if the electron is in a chemical bond. (Amounts and choices of amounts depend upon energy "change making," as explained later in the article.) When this happens, the electron becomes *excited*, and jumps to an "excited orbit." The process is called *absorption of energy* by the electron. (Since the actual motions are much more complex than flying

around an orbit, it is more correct to say that the electron jumps to a higher energy level, as explained in the article on Energy.)

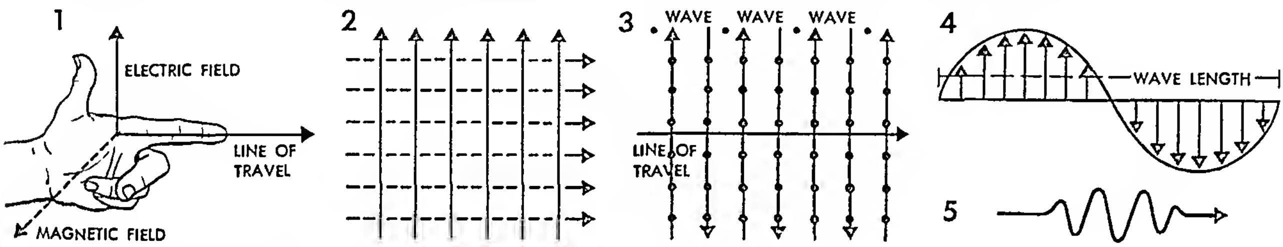
Any such jump, however, distorts the atom (or molecule) by placing the electron farther from the nucleus than in its normal state. The atom almost instantly relieves this strain by drawing the electron back to its normal orbit, or lowest energy level. Thereupon the excess energy is radiated away. It may be absorbed in surrounding matter or it may travel out into space. These discharges of excess energy from highly excited matter such as the material in the sun and stars, fires, molten iron, and the heated filaments in electric light bulbs account for most types of natural radiation.

The types are determined by the *degrees* of energy involved, both in the radiating matter and in the radiations. "Degree" is *not* the same as "total amount" of energy. In terms of heat energy, for example, degree is told by temperature, or average amount of energy in each molecule; the total amount, by calories (*see* Heat). In an atom, a degree is the amount of energy in any one electron, either in a normal or in an excited state. Total energy is the amount of energy in all electrons at all levels.

The difference can be compared to operating slot machines that sell articles for different coins. If a buyer has nothing but pennies, it does not matter whether he has one penny or a pocketful. He can buy only the few articles which sell for a penny.

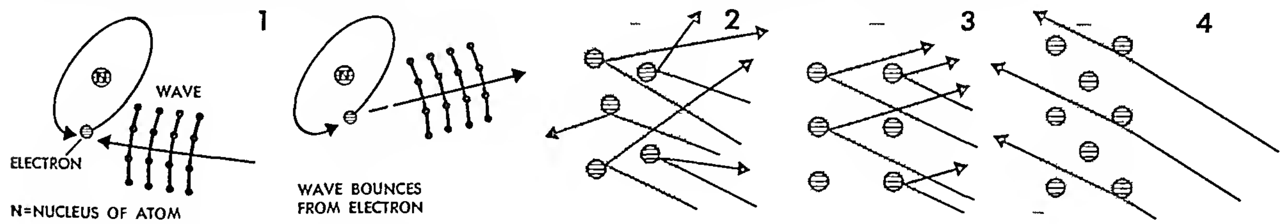
HOW ELECTROMAGNETIC WAVES AND ELECTRONS INTERACT

Some of the electrons in atoms can interact with the electromagnetic fields of passing radiations, from radio to X rays, to cause reflection, scattering, or refraction. Other interactions occur because the electrons in both molecules and atoms can absorb and reradiate energy whenever conditions are suitable. The general nature of each kind of interaction can be indicated, once the nature of an electromagnetic field in motion is known.



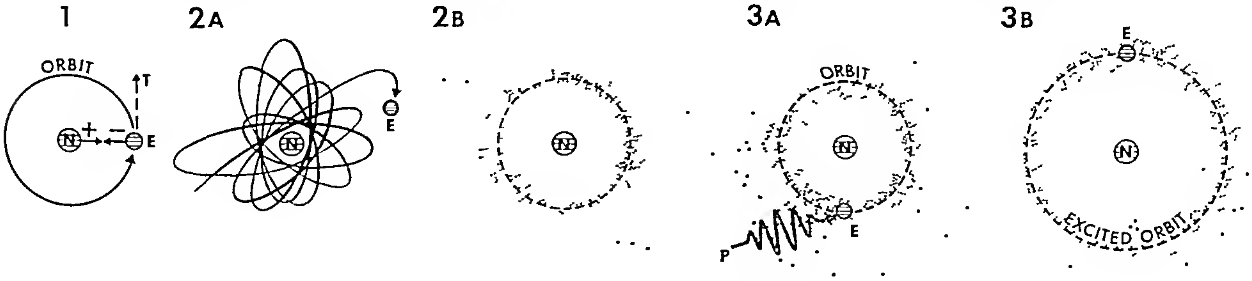
MOTION OF AN ELECTROMAGNETIC WAVE

1. In an electromagnetic wave, electric and magnetic fields vibrate at right angles to each other and to the line of the wave's travel in any given direction. 2. Both fields can be shown for one wave coming "head on" at the reader; but this view cannot show the line of motion. 3. A sidewise view can show the line of motion and several waves of one field. Lines of the other field can only be suggested with dots. 4. This shows in detail how the electric field changes strength in one direction, then the other, through one wave. A wavy line can also indicate this. 5. Actually, energy travels in *quanta*, or *photons*. These are wavelike packets often called *wavicles*. Such a packet, or wavicle, can be indicated in diagrams as shown here.



INTERACTIONS OF A WAVE AND AN ELECTRON

1. Here a part of an electromagnetic wave bumps into an electron in an atom and bounces off. The relations at the moment determine the direction of bounce. 2. In some situations, wave portions coming from one direction are bounced in random directions, and the radiation is *scattered*. 3. Other situations favor *reflecting* most of the radiation in one direction. 4. Still other situations result in merely bending (*refracting*) most of the radiation, before letting it through (*transmitting* it).



ABSORPTION AND RERADIATION OF ENERGY

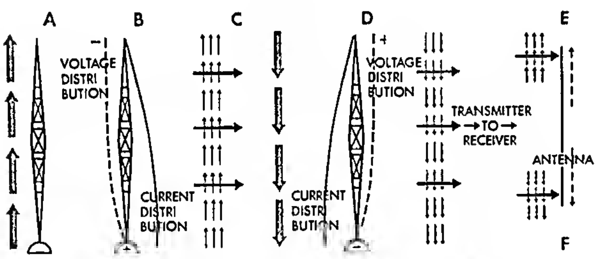
In an atom (1), unlike charges (+ and −) tend to draw an electron (E) to the nucleus (N), while the electron itself tends to fly free along line ET. The tendencies combine to produce motion that can be shown in simplified explanations as an orbit. Actual motions are much more complex (2A); but if different positions taken are shown by dots, the positions average out around the orbit (2B). An electron in a normal orbit (3A) absorbs a photon of energy (P) and jumps to wider motions that average out around an excited orbit (3B). The electron then reradiates the excess energy, as explained in the article.

If a buyer has nickels, he can buy a better level of articles. He may, however, find a machine which gives pennies in change for nickels. Then he can work a penny machine as well as a nickel one. He can do even better if he has dimes or quarters and can find a change-making machine.

Radiation interactions work out in somewhat the same way. The *kind* of interaction produced (infrared effects, some color of light, or an X ray) depends upon the degree or degrees of energy carried by the radiation which is striking. This corresponds to the kind or kinds of coins a buyer may have. The *amount* of interaction depends upon the total amount of energy that strikes. This corresponds to how many coins a buyer may have. Finally, excited electrons often can "make change." If they are excited to more than one level above normal, they can "spend" the excited energy at more than one lower level.

Countless experiments have proved that degrees of energy can be learned from frequencies (or wave lengths). Higher frequencies (with shorter wave lengths) carry higher degrees of energy. Lower frequencies (with longer wave lengths) carry lower degrees. This is somewhat like what happens when an object is shaken. Shaking at one rate produces one effect. Faster shaking may produce quite a different effect.

RADIO



Creating and Receiving Radio Waves

Low-energy photons, with low frequencies and long wave lengths, are used in radio. Low degrees of energy will work because radio methods use electrons which are the most loosely held (with the least amount of energy) of any that form parts of atoms. These are the so-called "free electrons" found in certain substances, notably metals (*see* Matter).

Each free electron counts as part of one atom; but it is held so loosely that it can wander readily from atom to atom. As long as the matter is undisturbed, the various wandering electrons keep each atom provided with its proper number of electrons. If, however, electric or magnetic force is applied from outside the atom under suitable conditions, this will set the free electrons streaming through the metal as *electric current.*

Should a driving electric force be reversed or alternated in direction at a rate of from thousands to millions of times a second in a suitable apparatus, the current will oscillate accordingly.

An oscillation in one direction (A) "piles up" charge (voltage distribution, B) that tends to repel (distribute) current the other way; and the combined disturbance sends one pulse of an electromagnetic wave radiating into space (C). The opposite oscillation reverses the former distributions and sends the other half of the wave (D).

When these "halves of waves" pass a suitably tuned receiving antenna (E and F), they send corresponding alternating surges of electrons through the antenna, thereby creating oscillating current. This current can be amplified to provide radio, television, or radar reception. (*See also* Radar; Radio; Television.)

Degree and total amount of energy show clearly here. A receiver tuned to a certain frequency, channel, or station will only receive pulses at the tuned in frequency. The total amount of power used by the transmitting station does not matter. This only tells how far the signals will reach.

Long and Short Wave Radio

The longer waves used for ordinary radio proceed outward in two effective ways. The portion which radiates close to the earth (the *ground wave*) interacts with the lower atmosphere and the ground itself. The result is that it follows along the curve of the earth until its energy is spent. This portion is the most effective in carrying broadcasts from transmitting stations to receivers within hundreds of miles, the range depending upon power used.

The fraction of the wave which radiates upward is reflected from ionized layers in the atmosphere (called the *Kennelly-Heaviside* and *Appleton* layers, after the men who developed the theory of their action). They lie from about 60 to 250 miles above the earth (*see* Atmosphere). Reflected waves strike the earth (or an ionized layer at a farther point) and provide long-distance radio transmission.

Reflection and Transmission

At frequencies greater than 30 million a second (30 megacycles, so-called *short waves*) the waves tend to be *transmitted* through the ionized layers. The difference between reflection and transmission depends upon the fact that each of the particles in the layer responds to electromagnetic waves in different ways at different frequencies. When interactions between short waves and free electrons in the layers will no longer produce reflection, receivers can respond only to waves that have come in straight lines (lines of sight) from the transmitters. Ground waves are useless at these frequencies, because they die out too near the transmitter.

PROPERTIES OF HIGHER FREQUENCIES

The photon energies carried in both long and short radio waves are too low to cause more than a few effects with the free electrons in antennas and radio circuits. With these electrons, any given frequency can only set up oscillations at a rate corresponding to the frequency. Higher frequencies, however, offer "change making" possibilities for all radiations from infrared through X rays.

This can happen because electrons that are bound within molecules and atoms have energies that match the higher frequencies and therefore permit absorption of photons having these frequencies and energies. If the absorbed energy is of a high enough degree, the electrons can divide it by reradiating photons with frequencies (and energies) lower than those of the absorbed photons.

The Quantum Theory of Energy

Discovery of how the "change-making" process works is one of the revolutionary advances made by modern physics since 1900. The modern explanation is called the *quantum theory*, from a term used by Max Planck, the first man to develop the view, in 1900.

The difference between older and modern theories resembles somewhat a painter and a tilesetter who arrive at a job with their supplies of materials and find that the surfaces to be covered are larger than expected. The painter can spread his material thinner and still cover his surface evenly. The tilesetter, however, cannot spread a tile thinner. He can only set the tiles farther apart.

The first example corresponds to the older theory that radiant energy could be spread out indefinitely. The second corresponds to the modern view that energy travels in tiny packets called quanta, or photons. These cannot be thinned out indefinitely (*see* Energy). A simple comparison of these views is shown in pictures at the bottom of this page.

Even after considerable spreading, most radiations still carry photons enough to provide dense bombardment, and the intensity of bombardment upon the same given area placed farther and farther from the source depends upon the square of the distance traveled. This is natural, since the spreading out occurs along each of two dimensions.

Another striking change from older theory is the modern view concerning the nature of the quantum, or photon, as a unit. Most units used in physical measurements, such as centimeters and grams, have fixed values. So do the erg and electron volt used in energy problems. A photon, or quantum, however, means an amount of energy which changes with the *frequency* of the radiation concerned. (This, naturally, has nothing to do with spreading or thinning out. The amount *at each frequency* remains invariable.)

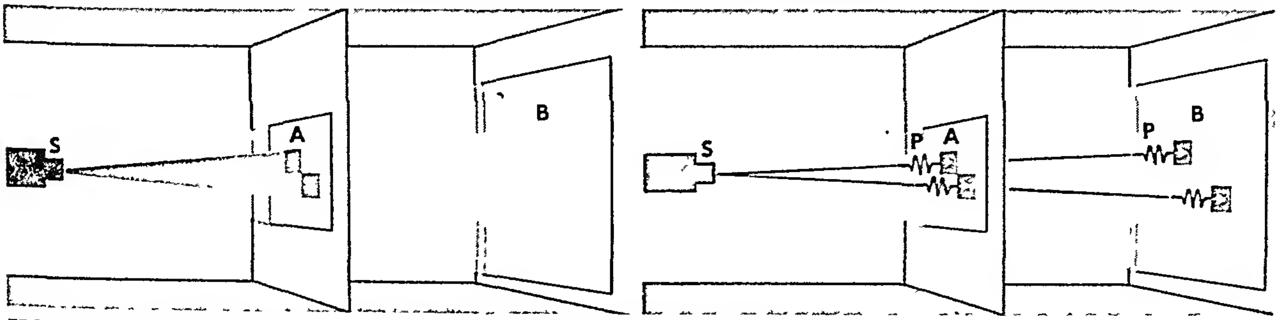
The energy value of a photon is given by a simple formula. In it, the energy for any photon is E. Its value is equal to a certain fundamental unit called *the quantum of action*, or *Planck's constant* (represented by the letter h), multiplied by the frequency (f) of the radiation which is carrying the quantum. Physicists use the Greek letter *nu* (ν) for frequency. Then the formula is $E=hf$ or $E=h\nu$.

Matter and Energy as "Particle Waves"

An important feature of the modern theory concerns the nature of matter particles such as electrons. This theory arose from a question concerning the nature of light which bothered scientists for nearly three centuries. Some experiments suggested that light must consist of particles, or *corpuscles*, traveling in straight lines called *rays* (*see* Light). Development of the quantum theory gave strong support to this view. Other experiments, however, suggested equally strongly that light must travel as wavelike pulses.

About 1925, physicists settled the question by saying in effect that "light is both corpuscular and wavelike." The corpuscular nature is recognized by saying that light and every other form of radiated energy are carried by quanta, or photons. The wave nature appears in the view that each quantum, or photon, *is a little bundle of waves*, sometimes called a *wavicle*. In some situations, the wave characteristics of the bundles make them act like waves. Under other circumstances the wavicle acts as though it were a simple particle, or corpuscle.

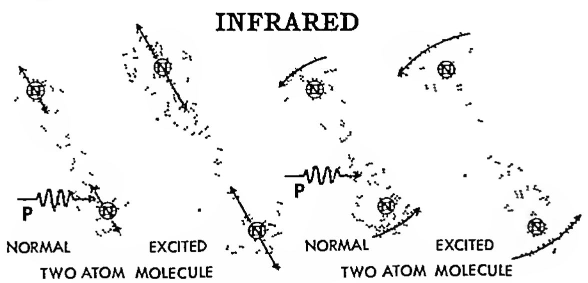
This theory that radiation has both wave and particle characteristics suggested that the particles of matter (atoms, electrons, and so on) might have wavelike characteristics as well. This became established in 1925, when C. J. Davisson and L. H. Germer found that a nickel crystal under bombardment by electrons deflected the electrons in a pattern which could only be explained as a wavelike response. From this, scientists built up the theory that every particle of matter is accompanied by or consists in part of, a *matter wave;* and in many situations, this wave is as important as mass in



HOW THE QUANTUM THEORY DIFFERS FROM OLDER VIEWS

To compare the old and the modern theories about light, imagine equal "bits" of energy leaving a source (S) and passing through a window to a farther wall. (Each view shows only two bits for comparison.) Under the old theory (left), each bit at window A spreads thinner as it travels and strikes a larger area (B) on the farther wall. Under the modern theory, each bit, called a *photon* (P), has exactly the same effect at B as at A. The spreading out of the entire shaft of light is accomplished by the photons traveling farther and farther apart. There are enough, however, to give the effect of covering the wall.

determining the response made by the particle to energy. The theory built on this view is called *wave mechanics*.



Infrared Affects Molecules in Many Ways

Many low-energy frequencies at which electrons may "make change" by dividing received energy carry the radiation called *infrared*. The name means "below the red," and it is used because infrared frequencies are next below those which carry red light. (*See also* Infrared Radiation.)

Radiations at these energy levels are excited whenever a mass of matter is heated to a sufficient temperature or range of temperatures. The heating may result from combustion (burning) or other chemical reactions. It can be produced by the passage of electric current or by subjecting some kinds of matter to disturbances from sufficiently powerful alternating electric or magnetic fields. Such applications of external energy add heat by shaking up the molecules in the heated matter.

Infrared frequencies can be absorbed by the electrons which are shared to form chemical bonds between molecules. These electrons are as a rule less firmly held than those within atoms (although more firmly held than the free electrons which are used in radio). Energy may also be absorbed in ways that make molecules spin or rotate faster, vibrate faster within their parts, or even break up and become something else.

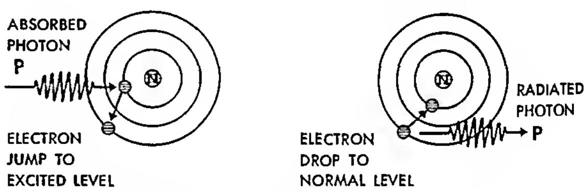
Since part of such effects is almost always increased motion, and increased motion means more heat in the affected molecules (*see* Heat), infrared is considered a great carrier of radiant heat. Other types of radiation also create heat when they strike matter, but in addition they produce strikingly different effects. Heating, on the other hand, is the most characteristic effect produced by infrared.

Heat can also be produced as part of the interactions that give reflection and refraction. Earlier in the article these interactions were explained by "bumpings and bouncings back" between portions (photons) of incoming waves and electrons in the matter struck by the radiation. While this is going on, however, some of the energy is absorbed; and part of the absorbed energy may cause faster motion in the molecules and therefore produce heat.

The electrons which pair off to form the chemical bonds in molecules (*see* Chemistry) may use their "change-making" ability to divide energy between responses to absorbed photons. If the absorption excites them to a sufficiently high level, they may return to the normal, or least-energy, state "by steps." In other words, they may get rid of only part of the excess energy between certain levels by devoting it to producing heat within the molecule. They reradiate the rest as photons of infrared or light.

Infrared radiation can be reflected and refracted if particles of the matter struck by the radiation have the characteristics needed to produce such effects. Rock salt, for example, will disperse infrared of various energies into spectra such as those of visible light (*see* Spectrum). Since the lines in the spectra correspond to various frequencies of energy radiated from excited molecules, these spectra yield valuable information concerning the molecular structure of the radiating matter.

Infrared illustrates how different forms of radiation overlap. Some of the shortest radio waves, or *microwaves*, can produce effects like those of the longest infrared waves. Some human beings can see somewhat longer wave lengths than most people can. To those with exceptional eyes, the wave lengths are visible light; to the others, infrared. (For further explanation of overlapping radiation, *see* Energy.)



Radiations from Electrons Within Atoms

Waves of frequencies next higher than those of infrared are the carriers of visible light. They are radiated whenever matter is heated sufficiently to emit photons having the necessary energy (and corresponding frequency) at intermediate levels of excitation. Such excitations may be provided by heating or by atomic collisions within the excited matter. Either condition makes electrons jump to higher levels or even knocks them out of atoms. When the excited electrons fall back or when new electrons are captured to replace those lost, photons of light are emitted. Lower levels of excitation meanwhile produce infrared radiation.

Some chemical reactions produce radiation at light-wave frequencies without accompanying radiation of heat. This happens in phosphorescence and in the "cold light" given by fireflies (*see* Fireflies; Phosphorescence). Fluorescence can also give a considerable degree of cold light.

Different Colors in Light

The nerve endings in our eyes see differences in wave length (and photon energy) of incoming light as separate colors. Colors are reflected alike but are refracted differently. The percentage of light which may be reflected or refracted also varies

with color. Differences in refraction of different colors of light while passing through a lens are extremely important in devices such as cameras and telescopes (*see* Lens). They also enable a glass prism to spread out a mixture of colors into a spectrum (*see* Spectrum).

Refraction depends not only upon color but upon the arrangement of electrons in the refracting substance. A prism of crown glass, for example, refracts colors by quite different amounts than does an identically shaped prism of flint glass. The flint glass has a different chemical composition and, therefore, a different electronic arrangement. The electronic arrangements in various substances also determine which colors will be refracted, transmitted, or absorbed.

Various color effects arise from variations in reflection and absorption. A polished metal surface, for example, reflects all colors, although not equally in most cases. Copper reflects reddish colors almost completely but absorbs some green and blue. This gives "copper color." Silver looks white because of more equal reflection. A body that absorbs all colors looks black, because it gives no reflected light. (*See also* Color.)

Fluorescence and Photochemical Effects

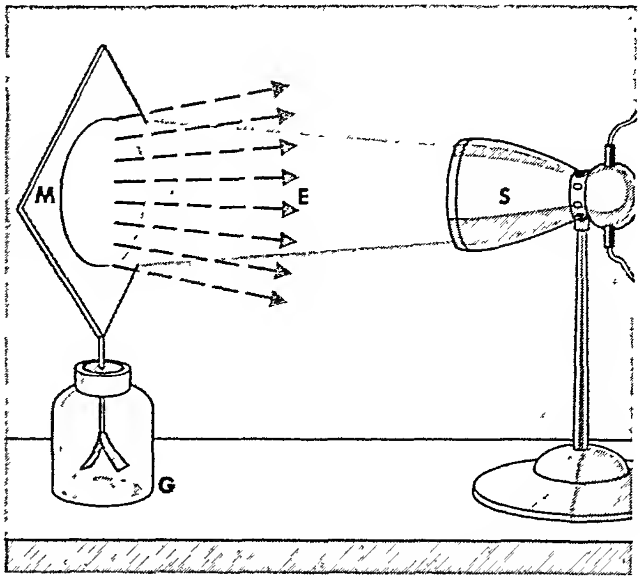
When light is received by the eye, almost all the energy is absorbed in chemical reactions. Many substances, however, will absorb and reradiate light, by the process of *fluorescence*.

The colors in the exciting light are determined by the energies (and frequencies) of the photons which carry it. If these energies are sufficient to excite electrons in some substance which they strike to more than the first level of excitation, the electrons can drop back to their normal, or least-energy, states by any "choice of steps" between their excited and their normal levels.

At each drop, any electron will lose only part of the energy which it absorbed. Therefore the photon which it reradiates from this drop will have a longer wave length and a lower frequency than those of the absorbed radiation. A striking example is that of chlorophyll, the coloring matter in plants which looks green in sunlight. If radiated with orange light only, it fluoresces a deep red.

Another example is a fluorescent light. It obtains energy from excited mercury vapor in its tube. The vapor gives a high proportion of high-frequency, invisible ultraviolet, which falls upon substances called phosphors on the inside lining of the tube. These reradiate colors of visible light. The process gives much more visible light and much less infrared (which goes only into heating) than would the same amount of energy used to heat a filament in an ordinary incandescent bulb.

Photons of light also carry the right amounts of energy for certain *photochemical* effects. The photons excite the electrons in the chemical bonds of some molecules to the point of altering or breaking the bond. This happens in photography. Absorbed photons of light break down certain silver salts and leave pure silver in the film or plate to register the photographed picture. (*See also* Photography.)



SHOWING THE PHOTOELECTRIC EFFECT

Here a metal plate (M) is given a negative electric charge. Part of the charge enters a gold-leaf electroscope (G), and the leaves fly apart. If now the plate is flooded with ultraviolet from the source (S), the leaves fall together, showing that the charge is leaking away. This happens because the radiation is driving electrons (E) out of the plate.

Biologically Powerful Ultraviolet

Next higher than visible light in frequency and photon energy—and also shorter in wave length—is the type of radiation called *ultraviolet*. This radiation is produced generally by the same electrons which produce light waves and weak X rays but within the ultraviolet range of energy-level jumps.

Ultraviolet is particularly noted for its ability to affect cells in living tissues. The ultraviolet in sunlight causes sunburn, tanning, and freckles. Ultraviolet can change sterols in the body into various forms of vitamin D (*see* Vitamins). It has energy enough to kill many unicellular organisms. It is used therefore in hospitals and elsewhere to kill disease germs. (*See also* Ultraviolet Radiation.)

Production of Photoelectric Effects

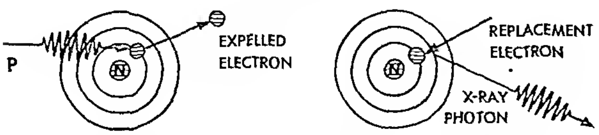
The photons of both light and ultraviolet carry enough energy to drive electrons with their negative charges from the atoms of certain metals. This reaction is called the *photoelectric effect*. It is the basis of so-called "electric eyes" (*see* Photoelectric Devices).

The electrons involved are the loosely held, or free, electrons which carry electric current through metals, as explained earlier. The amount of energy required to drive them out varies with the kind of metal. In other words, the metal must be struck by photons having a certain minimum frequency, before there will be any effect at all. Thereafter, increase in the intensity of the radiation increases the amount of effect. All this is to be expected, since the

strength with which free electrons are held within metals varies with the kind of metal. They will respond when struck by photons having the necessary energy; how many electrons will be emitted depends upon how many photons strike.

Common metals such as aluminum require frequencies in the ultraviolet before they become sensitive. Cells designed to detect visible light can use metals of the alkali group, such as cesium. But these metals are extremely active chemically, and they can only be kept in condition for use by applying them as thin coatings on the inside, air-free surfaces of vacuum tubes.

X RAYS



Electrons Expelled from Atoms Produce X Rays

This penetrating kind of radiation is commonly generated by directing a stream of electrons at extremely high speed against a metal target in a vacuum tube. The bombarding electrons emit X rays as they lose energy through collisions with electrons in the atoms of the metal. They also can knock innermost electrons clear out of the atoms, as shown in the picture. The atoms then regain the lost electrons in various ways; and X rays of various frequencies are emitted, according to how the regained electrons fall into the vacated place.

An atom may capture an electron from surrounding space and draw it into the vacated place. Again, it may fill the vacated place with one of its outer electrons and then capture an electron from the surroundings to fill this place. Since the expulsions from inner levels require high energy, the fallbacks, which can occur all at once or by steps, emit X rays which have corresponding energies and frequencies. (While X rays are being emitted, the target also gives off infrared, visible light, and ultraviolet and becomes extremely hot.)

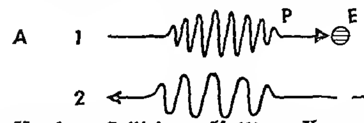
Materials are transparent in varying degrees to X rays, although they are opaque to visible light. The electrons in the atoms of the penetrated matter cannot react fast enough to affect the electromagnetic fields carried by the high-frequency, high-energy X-ray photons. Some photons will be absorbed and cause heating and reradiation; but many will pass through and then affect a fluorescent screen or photographic film. Either method gives a picture of more and less transparent portions of the substance traversed. (*See also* X Rays.)

The Compton Effect with X Rays

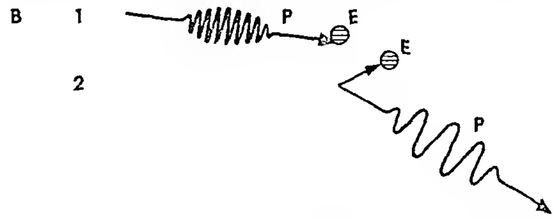
In 1923 Arthur H. Compton announced his discovery that X-ray photons can strike electrons and drive them out of matter. The X-ray photons bounce from the collisions in new directions and with increased wave lengths. They have given some of their momentum and kinetic energy to the struck electrons, just as would happen if a flying tennis ball struck a billiard ball at rest on a billiard table. To do this the photon must have definite mass, like the tennis ball.

HOW X RAYS DRIVE ELECTRONS

If X rays hit a carbon target, they drive electrons from the target. Each X ray gives some of its energy to whatever electron it hits, and its wave length is increased. The X rays also are scattered.



A. *Head on Collision.* If (1) an X-ray photon (P) strikes an electron (E), it will fly back (2), and drive the electron forward.

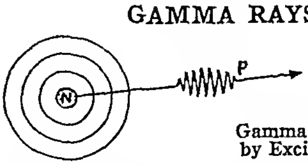


B. *Glancing Collision.* In such collisions (1) both the X-ray photon (P) and the electron (E) fly off in slanting directions (2) from the original photon track.

This effect was the first conclusive proof that photons can behave like corpuscles or particles. Because of it, physicists decided that photons of other electromagnetic radiation must also have corpuscular characteristics, as well as being wavelike. (For further explanation, *see* Energy.)

X rays can be diffracted by certain crystals and arrayed into diffraction patterns which reveal the crystal structure. Different frequencies can also be arrayed into lines on a photographic surface, thus forming a spectrum. X-ray diffraction is immensely valuable in studying the structure of matter.

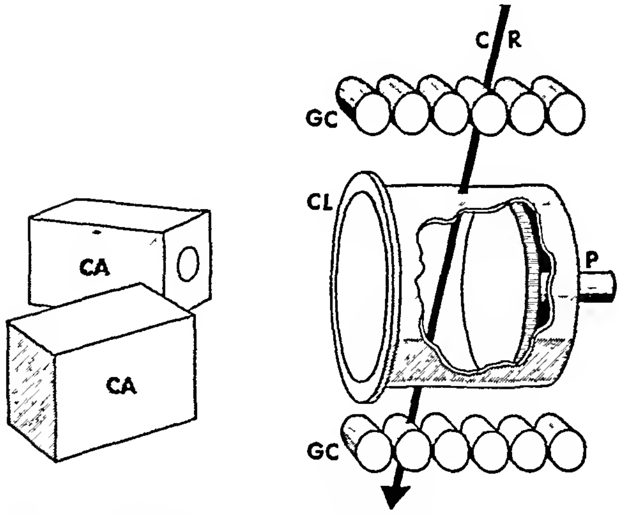
GAMMA RAYS



Gamma Rays Are Given Off by Excited Nuclei of Atoms

Gamma rays resemble X rays, except for their origin. X rays arise when inner electrons are expelled from atoms. Gamma rays arise when the nuclei of atoms become excited and reradiate some or all of the exciting energy as electromagnetic radiation.

Gamma rays first were found in the process of natural radioactivity in the same years when early knowledge of X rays was developing. At the time, gamma rays had higher frequencies and energies than those of any X ray known, and this was thought to be distinctive, since gamma-ray energies seemed beyond man's reach. Modern equipment, however, can generate X rays with frequencies higher than those of any radioactive gamma ray and others with frequencies in the ultraviolet range. Difference in origin is therefore the only distinguishing feature.



CLOUD CHAMBER FOR COSMIC RAYS

A cloud chamber (CL) is arranged between rows of Geiger counters (GC). When a cosmic-ray particle (CR) strikes through the cloud chamber, it also passes through the counters. They act through electrical devices not shown to pull back the piston (P) in the chamber. This forms droplets on the ions left by the ray. The droplets form a track which is photographed by two cameras (CA).

How Nuclei Become Excited

Protons and neutrons are held together in nuclei by strong nonelectrical forces. The nuclei of radioactive elements, however, such as those of uranium and radium, have more particles than can be held permanently. From time to time they relieve this state of instability by discharging an alpha or a beta particle. This may leave the nucleus with excess exciting energy; and it relieves the excess by emitting a gamma ray. (*See also* Radioactivity.)

Gamma rays can also be generated by bombardment with high-energy particles. The bombardment may cause transmutations, like those of natural radioactivity; or a "near hit" may merely shake up the nucleus. In such cases, the nucleus emits the "shaken up," or excess, energy as a gamma ray.

Gamma rays complete the array of electromagnetic radiation that begins with radio waves. Some radiations, or mixtures of them, can also be made to create special effects that are of value in certain investigations. An important example is the Raman effect.

The Raman Effect

Under certain conditions, molecular bonds give a reradiation of light called the Raman effect. Sir C. V. Raman of India, with K. S. Krishnan, discovered the reaction in 1928. The effect is created by flooding light upon a sealed tube filled with liquid which contains the substance under study. The liquid scatters most of the light, but also gives off some faint light which can be spread into a spectrum. This spectrum shows the original frequency (or wave length) and also both higher and lower frequencies.

The altered frequencies can only be explained as a result of collisions between incoming photons and electrons in the bonds of molecules in the liquid, once these electrons have become excited by radiation with strong light. For the higher frequencies, the bonds add the photon energies to their already excited states, then reradiate the sum of the energies as a single photon. If the bonds divide the total energy between exciting the molecule and reradiating light, this light may have lowered frequencies. Since these results depend upon energy levels in the bonds, and these in turn depend upon the character of the bonds, the Raman effect yields much valuable information about the structure of molecular bonds.

Tremendously Powerful Cosmic Rays

A highly mixed array of phenomena which include the most energetic reactions between energy and matter in all nature is grouped together under the general term *cosmic rays*. Actually, there is more than one type of "ray," and these produce many subatomic particles. Some of these particles are not evident elsewhere in natural phenomena.

The phenomena begin with a bombardment of the earth by protons (alone or in greater abundance than other particles) arriving at tremendous speed from somewhere in outer space. These protons (called *primary* cosmic rays) arrive at the outer atmosphere with energies of from billions to scores of billions of electron volts. In 1954, for example, Marcel Schein announced the discovery, in a stack of photographic plates exposed 100,000 feet above the earth, of tracks made by two electrons which seemed driven by a blow from a particle having an energy of 10 million billion electron volts. This is 50 million times the energy released by fission of a uranium atom.

The source from which the protons come is as yet unknown. It is also uncertain what kind of nuclear transformation might give rise to them, since the energies involved are far greater than any seen on the earth.

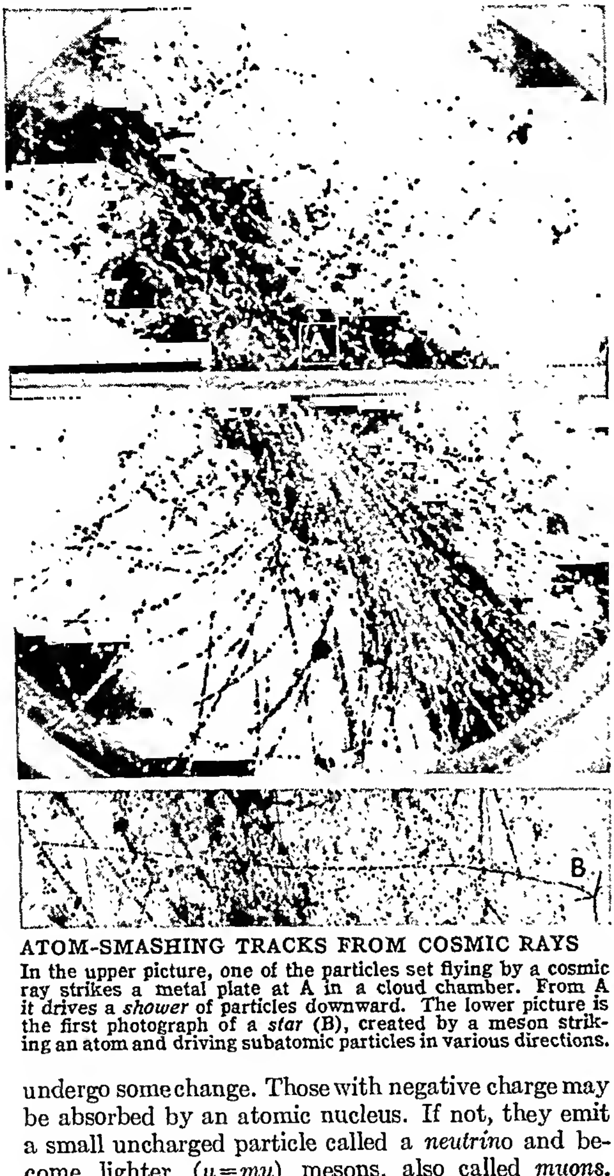
Successive Transformations in Cosmic Rays

Most of the protons strike atoms in the outer atmosphere at heights of from 10 to 12 miles above the earth, and the resulting products strike down, smashing atoms and creating photons of electromagnetic radiation on the way. The mixture bombards every square inch on the surface of the earth with 10 to 15 blows every second. Only the extremely tiny masses in the bombardment save us from being aware of this and from being harmed.

The first product of collisions between primary cosmic rays and atoms is an array of subatomic particles called *mesons*. These appear from atomic nuclei in some way not yet well understood (since nuclear masses are accounted for by protons and neutrons); and they probably carry away the tremendous excess of energy imparted when the atom is struck.

These mesons have a particle nature, with masses intermediate between those of electrons and protons. They may have positive or negative charge or no charge. They are usually called *pi* (π) mesons, the Greek "p" standing for "primary," or *pions*.

These mesons seem themselves to carry excess energy, for within a few millionths of a second they



ATOM-SMASHING TRACKS FROM COSMIC RAYS
In the upper picture, one of the particles set flying by a cosmic ray strikes a metal plate at A in a cloud chamber. From A it drives a *shower* of particles downward. The lower picture is the first photograph of a *star* (B), created by a meson striking an atom and driving subatomic particles in various directions.

undergo some change. Those with negative charge may be absorbed by an atomic nucleus. If not, they emit a small uncharged particle called a *neutrino* and become lighter ($\mu = mu$) mesons, also called *muons*. Positively charged mesons also undergo this decay.

Uncharged mesons decay into two high-energy protons. A negatively charged *mu* meson decays into an electron and two neutrinos. The electron plunges on, striking atoms and producing high-energy (mesonic) X rays. Positively charged *mu* mesons yield a positron instead of an electron and a neutrino.

Detecting Cosmic-Ray Effects

Various flying particles can be detected with stacks of Geiger counters. The counters are connected to electrical recorders in a way that cancels out impulses caused by particles passing through in one general direction (top to bottom or side to side). Those passing in the other direction can be counted directly or used to "trigger" a cloud chamber. A particle passing through the chamber ionizes gaseous particles along its path. The triggering action releases vapor to form droplets on the ions and operates a camera or cameras in time to photograph the track formed by the droplets.

Another method uses stacks of photographic plates. Any particle striking through the stack leaves a trail of silver grains (as though the plates had been exposed to light). The trail can be developed and studied directly. Electric charges on particles can be detected by placing the detecting apparatus in a strong electric field. The field makes a charged particle follow a curved path.

Two striking patterns are observed among cosmic-ray effects. When an atom is struck, it may burst, and products fly in various directions. Such a pattern is called a *star*. Another type of pattern occurs when products of a collision stream toward the earth, driving other particles and radiation from atoms, and these in turn still others; and the interactions spread out in a fanlike pattern until the earth is struck. Such patterns are called *showers*. Some showers may strike a million square feet of area with perhaps a million particles.

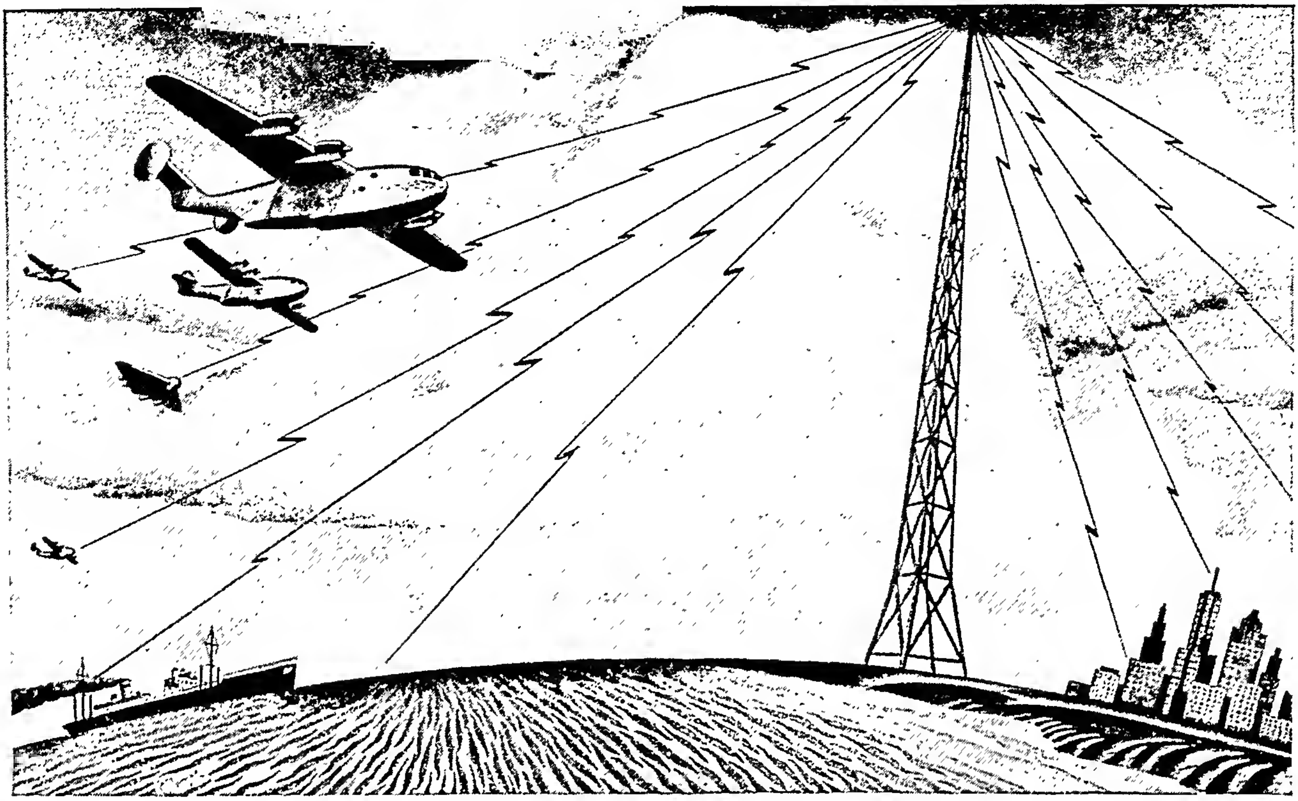
High Lights in Cosmic-Ray Research

Cosmic rays were discovered between 1911 and 1914 by V. F. Hess and Werner Kolhörster through observations made by instruments carried into the atmosphere by balloons. Other physicists, including R. A. Millikan and G. H. Cameron, used a sealed electroscope sunk in lakes or placed deep in mines to measure the penetrating power of particles which got through the cover and struck the instruments.

In 1927–28, while on a voyage from the Netherlands to Java, the Dutch physicist J. Clay discovered that cosmic-ray products reach the earth in least amounts at the magnetic equator and that the intensity increases toward either magnetic pole. This change, called the latitude effect, suggested a deflection by the earth's magnetic field. Only charged particles with the greatest energies could resist this and reach the earth at the magnetic equator; but particles with less energy could reach the earth in greater numbers in higher latitudes. This fact (and other observations) established protons as the most likely constituents of primary rays.

In 1948, Eugene Gardner and C. M. G. Lattes released mesons by bombarding atoms in a cyclotron, using 380 million volts of energy for the bombardment. Today many powerful machines are producing mesons, thereby making it possible to use convenient laboratory methods instead of sending up balloons and rockets—although for the study of reactions at higher energies, primary cosmic rays are still the only available source known to man. This new power of experimentation speeds research into the nature of atomic nuclei and the forces and energies involved in their reactions. By 1954, research had revealed more than 20 kinds of particles with meson characteristics. Whether or not some of these may be "transition products" between other forms of mesons is not known. Included in this array of particles is the *hyperon*, with a mass greater than that of a proton.

The HOW *and* WHY *of* RADIO COMMUNICATION



RADIO. The space about you is literally quivering with intense activity. Voices talking in English, French, German, Italian, Spanish, Japanese, and other tongues—dispatches intended for men who live in remote polar regions or lonely Pacific islands; programs of concerts, or lectures on their way from all the more important cities the world over. There are messages in code flashing from continent to continent, signals from ships at sea, from airplanes above the clouds. In fact, if some device could turn into sound simultaneously *all* the radio waves that are passing through your room at this very moment, you would hear the greatest jumble of noise, languages, and music that was ever caught by human ear.

The whole story of radio is the story of how these silent and invisible waves are produced in the first place, how they are detected and disentangled from one another by the instruments which receive them, and how these instruments magnify and translate them back into sounds for our ears to hear.

First, let us get rid of the common notion that radio waves consist of electricity itself passing through space like some kind of invisible lightning. Though electricity produces these waves, they are something different. They belong to the group of wave motions that includes also heat waves, light waves, ultraviolet rays, X-rays, gamma rays of radium, and so on, all of which move through space at the same rate of about 186,000 miles a second, or to use the more serviceable figure, 300 million meters a second. (*See* Light; Radiation; Spectrum and Spectroscope.) The difference between each of these types of wave motions depends, then, not upon their speed, but upon what is called their *frequency*, that is, the number of waves that are generated per second.

Wave-Length and Frequency

Of all the known types of radiant energy, radio waves have the lowest frequencies; but even these may run as high as millions a second. Therefore it is often convenient to use *wave length* instead of frequency. "Wave length" is the distance one wave travels before the next one starts. Suppose waves are going out with a frequency of a million a second—that is, one millionth of a second apart. How far will a radio wave go in one millionth of a second? (Its speed, remember, is 300 million meters a second.)

Answer: 300 meters. It is called a 300-meter wave. From this we see that dividing 300 million by the frequency gives us the wave length and, vice versa, dividing 300 million by the wave length gives us the frequency. High frequencies mean short waves; low frequencies mean long waves.

Now let us see how radio waves are produced. The commonest type of electric current used in houses is a 60-cycle, alternating current. This means that instead of flowing continuously in one direction through the wires as does a current from a battery, the current surges first in one direction, then comes to a complete stop, then surges back in the opposite direction, making 60 back-and-forth movements or *cycles* every second. This behavior of an electric current is called *oscillation*.

Such oscillating currents produce disturbances in the space around them, generating radio waves that spread in all directions, much as a stone thrown into

a pond makes water waves, or the vibrating string of a guitar makes the air waves that we call sound. Each cycle of the current produces a wave, so that the number of cycles in the electric circuit and the frequency of the waves sent out from it are the same. Of course, a frequency of 60 waves a second, such as the house current produces, is far too low for practical radio transmission (300 million÷60=5,000,000-meter wave); but it serves to illustrate the nature of oscillating currents. Why these currents make radio waves is a question connected with the fundamental theories of physics, explained in the articles on Energy, on Matter, and on Radiation. Here we need only consider how oscillating currents are produced.

"Damped" and "Continuous" Waves

When electricity leaps across a gap, like the spark from your finger after you have shuffled your feet on a carpet, or the spark from a Leyden jar, the first discharge carries an excess of electricity over, so that a part of it jumps back again immediately. But, to a lesser degree, this second discharge is again excessive, so that the back-and-forth movement continues until the electrical balance is restored. Of course, all this takes place in a very small fraction of a second, making it seem like a single flash. Fig. 1 indicates how a succession of such spark discharges behave, yielding what is called a "damped" oscillatory current, in which the oscillations are damped or diminished gradually from maximum to zero. They generate radio waves of corresponding character, and it was with spark-making apparatus that the first wireless telegraphy was accomplished, variations of short and long spark discharges being used for the dot-and-dash code signals. Because of the extreme simplicity of the method, some spark transmission is still used.

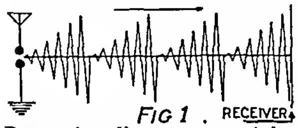


FIG 1. Damped radio waves sent by spark set. Each set is caused by one spark, and they are shown traveling through space, instead of being on the usual "time axis." Each group actually contains thousands of oscillations.

On account of their uneven and interrupted character, however, damped radio waves are unsuited to radio telephone work or to broadcasting. A continuous, regular flow of waves is required of the form suggested by Fig. 2. It is possible to produce these undamped waves at low frequencies with alternating current generators, but their frequency range is limited by the highest speed at which the generators can be driven. The almost universal sources of radio waves today are special vacuum tubes. Under conditions described later, they yield oscillating currents of virtually any frequency desired.

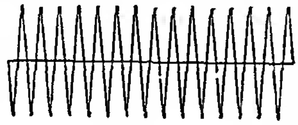


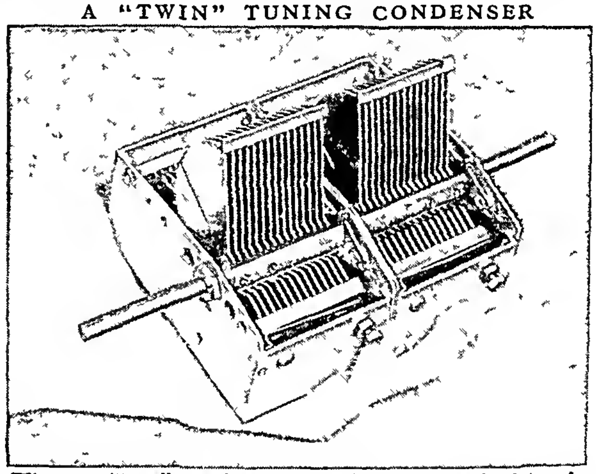
FIG 2. Undamped or continuous radio waves such as given by a high-frequency generator or by an oscillating vacuum tube. Upon this type of carrier wave sound fluctuations are impressed as in Fig. 8.

What controls the frequency of an oscillating current and, in turn, the frequency of the radio waves it sends out? It depends entirely upon the character of the circuit in which the current is flowing. Every electrical circuit has three properties that play an important part in radio transmission and reception. First, it has *resistance,* which corresponds to friction in a machine, and tends to reduce the energy of the current. Second, it has *inductance,* which corresponds to the inertia of mechanics, and tends to oppose *changes* in the amount and direction of current flow. Third, it has the ability to accumulate electric charges, which is called the *capacity* of the circuit, and which can be compared to the storing of energy in a coiled spring. Once again you must go to the article on Electricity for a more detailed explanation of these properties. Here we will show merely their practical application to radio circuits.

"Tuning" with Inductance and Capacity

The latter two factors—inductance and capacity—are the ones that control frequency. If we increase the inductance or the capacity, or both, in a circuit, we lower its frequency, and vice versa. While it is true that all parts of a circuit have a certain amount of inductance and capacity, in practical radio circuits the inductance centers chiefly in the *coils* and the capacity in the *condensers* (*see* Electricity).

A "TWIN" TUNING CONDENSER



When you "tune" a radio set you are turning movable plates of a condenser like this. Maximum capacity is obtained when the movable plates are completely interleaved in the fixed ones.

The larger the number of turns of wire in a coil, the higher, in general, is its inductance. The larger or more numerous the plates of a condenser, and the closer the plates on one side are "coupled" with those on the other side of the circuit, the higher is its capacity. For ease in changing from one frequency to another, radio circuits are equipped with *variable condensers* in which, by turning a knob, one set of plates can be moved gradually in and out of coupling with another set of plates, thus raising or lowering the capacity. These variable condensers can be seen inside any receiving set. Sometimes the coils are equipped with switches to control the inductance by including more or fewer turns of wire in the circuit.

Let us suppose that we have a circuit with its capacities and inductances so adjusted that it oscillates at a frequency of 600 *kilocycles.* (A kilocycle is 1,000 cycles.) This may also be expressed as 0.6 *megacycles,* a megacycle being 1,000 kilocycles. This, as calculated by the method given previously, will produce a 500-meter wave. How is the receiver to be adjusted to pick up that wave and none other? Simply by adjusting the capacities and inductances of the receiving circuit to correspond with those of the sending circuit. When that is done, the two circuits are said to be in *resonance* with one another, and each of them is likewise *resonant* to a 600-kilocycle current.

Explaining What "Resonance" Means

Electrical resonance becomes clear if we compare it to sound resonance. When we stretch two violin strings near each other, adjusting their length and tension so that both are tuned to the same pitch, and then pluck one of the strings, the other will start vibrating in unison with it. The energy of the sound waves from the first string is exceedingly small, yet as the waves strike the second string in quick succession and at exactly the intervals suited to its natural vibration period, they set it in vigorous motion, just as a succession of gentle pushes at just the right moment will keep a swing going higher and higher. In much the same way, radio waves, traveling over vastly greater distances and carrying only a very tiny amount of energy past any given point, still have the power to set up an oscillating current in any circuit that is resonant to them. Just as in the case of the two violin strings, the process of matching the electrical resonance of one circuit with another is called *tuning.*

Wave "Amplitude"

This brings us to another characteristic of radio waves that we have not yet considered. It is called *amplitude.* Suppose, for example, that our transmitting circuit is tuned to 600 kilocycles and we suddenly feed more power to it; what happens? Obviously the frequency will not change, for the inductance and capacity remain the same. All that the extra power does is to produce bigger waves, that is, waves of greater amplitude at the same frequency. Fig. 3 illustrates this point. It is an important point to bear in mind, since it is by variations in amplitude, as we shall see, that radio waves are made to carry sound signals in most broadcasting systems.

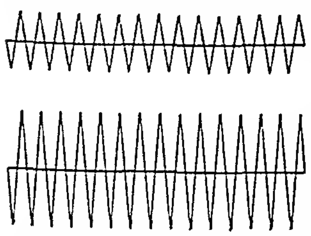


FIG 3

Both of these waves have the same frequency, but the lower one has twice as much "amplitude" or power as the upper one. Sounds, acting through a microphone, make the amplitude of radio waves fluctuate, as shown in the top part of Fig. 8.

The simplest form of transmitting circuit consists of the elements represented diagrammatically in Fig. 4. The spark coil, operated from the battery, provides the power in the form of a damped oscillating current across the spark gap; the inductance consists of a simple coil; the capacity is provided in part by a variable condenser (not shown) and in part by the capacity between antenna (aerial) and ground. When a set is grounded (connected to the earth) the antenna and the ground act as the two plates of a giant condenser, the capacity of which depends on the size and the height of the antenna. This is one reason why the selection and adjustment of the antenna plays an important part in both transmission and reception of radio.

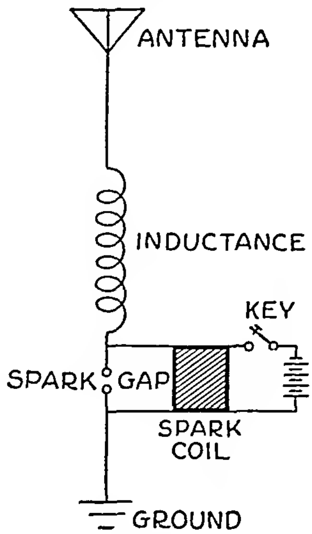


FIG 4

When the key is pushed down sparks jump the gap and continue until the key rises. A short series of sparks makes a dot, a long one makes a dash, thus enabling the operator to send code messages. The parallel lines at the right represent the battery. For simplicity, the variable condenser with which the circuit is tuned, as in Fig. 5, has been omitted.

Fig. 5 represents the simplest form of receiving circuit, using a crystal detector. Although neither spark transmission nor crystal reception are greatly used nowadays, they serve to illustrate with a minimum of confusing details the essential principles of radio practise.

We will suppose now that the sending operator wishes to transmit the letter "A," consisting of a dot and a dash. He pushes the key down for a brief instant and a short series of spark discharges leaps across the gap to make the dot. He then holds the key down

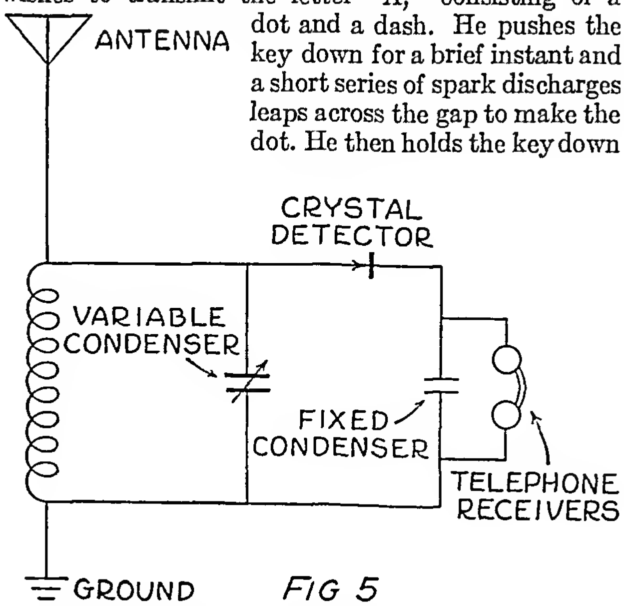


FIG 5

This represents a receiving circuit with a crystal detector. It is tuned to resonance with the incoming signal by means of the variable condenser. The crystal rectifies the signal by allowing only one-half of the oscillating current to pass through it, as explained in the text. The fixed or "by-pass" condenser permits the high frequency oscillations to escape through it to the ground, while the slower signal impulses pass through the telephone receivers where they can be heard.

a trifle longer, producing a longer series of discharges to make the dash. Out from the antenna goes a train of waves that can be graphically represented as in Fig. 6. Here as well as in Figs. 1 and 7, the waves are shown traveling through space, the first emitted being farthest from the sender. The usual diagram, however, shows the first at the left, the arrangement being according to *time* of emission.

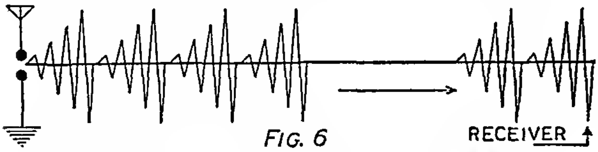


FIG. 6

These waves carry the letter "A" in code—a dot and a dash.

These waves reach the receiving antenna and there set up an oscillating current of exactly the same form. How is this signal to be heard in the telephone receiver? As you know, if you have examined such a receiver or read the Telephone article, it consists of a magnet with small coils of wire around its poles. Fluctuations of current through these coils (provided they are not too rapid) affect the pull of the magnet on the diaphragm of the receiver, making it vibrate in tune with the current. But, of course, neither the magnet nor the diaphragm can act fast enough to record the separate oscillations of a high-frequency radio current, and even if they could, the vibrations would be far above the range of human hearing (*see* Sound). However, the oscillations are divided into groups, corresponding to the number of spark discharges that jumped the gap of the transmitter, and their rate (from a few hundred to a thousand a second) is well within the range in which the diaphragm and our ears can respond to vibrations.

"Rectifying" and "Detecting"

Even so, we cannot get results by feeding this series of impulses directly into the telephone receiver, because half of each impulse consists of current moving in one direction and half of current moving in the opposite direction. This would neutralize the effect on the magnet and the diaphragm would not vibrate at all. So we introduce into the circuit a type of crystal which has the peculiar property of allowing electric current to pass only in one direction. There are several such crystals, those of silicon, galena, and carborundum being among the most common. The result is to suppress half of the current, producing an effect that we illustrate in Fig. 7.

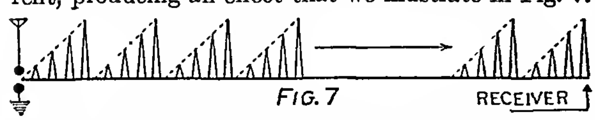


FIG. 7

The letter "A" as shown in Fig. 6, after it has passed through the crystal detector. Only half of the signal is left.

The current that gets through now consists of a series of one-direction impulses that can actuate the magnet of the receiver and register on the diaphragm with a buzzing noise—a short buzz for the dot and a longer buzz for the dash. The crystal in this case is called a *rectifier* or a *detector*. Presently we shall see how a vacuum tube can be made to act as a detector. But first let us consider how the transmission of sound compares with the spark transmission method just described.

Carrier Waves and Modulation

As we noted earlier, a current of continuous undamped oscillations is required (*see* Fig. 2). We will suppose we have a circuit producing such a current. Into this circuit we introduce a microphone, which is nothing more than an extremely sensitive telephone transmitter. As long as no sound goes into the microphone, the circuit sends out high-frequency waves that are all of the same energy or amplitude, and therefore inaudible in a receiver. They are called *carrier waves*. But as soon as we talk or play music into the microphone, its diaphragm vibrates in exact response to the sounds, and its vibrations affect, just as they do in a telephone line, the quantity of current that flows in the circuit. If the tones we make are faint, the vibrations are small and produce only small increases or decreases in the current; loud tones produce large changes; high-pitched notes yield rapid current fluctuations, while with low notes the fluctuations are slow.

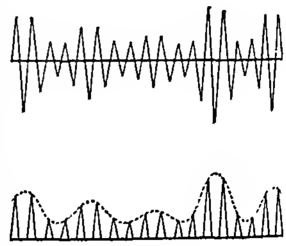


FIG 8

Above is a continuous carrier wave, as shown in Fig. 2, after sound variations have been impressed upon it. Below is the same signal after it has been rectified as the text explains. The dotted line represents the sounds created in the telephone receivers or the loudspeaker by the varying rectified current.

Exactly as the current in the microphone circuit varies in response to the sound, so does the amplitude of the carrier waves, as indicated in the upper diagram of Fig. 8. This method of impressing *audio-frequency* waves upon *radio-frequency* waves is called *modulation*. When the current set up in the receiving circuit has been rectified, we get the result shown in the lower diagram. The wavy line represents the variations of direct current energy that will reproduce the sounds in earphones or loudspeaker.

So far we have examined the essential principles involved in sending and receiving radio waves. These principles apply as well to the most powerful sending and receiving methods in use today as they did to the first spark-and-crystal methods of radio's infancy. However, the practical application of radio would probably still be in the infant stage had not the radio vacuum tube been invented. This amazing device bears many names—audion, triode tube, thermionic valve, etc.—but the common practise in America is to call it simply the *radio tube*.

The quickest way to grasp the construction and behavior of a vacuum tube is to see how it works in a simple one-tube receiving circuit such as is represented graphically in Fig. 9.

The filament of the tube is heated by the current from the "A" battery in the same way as a flashlight lamp is set glowing by its battery. Such heated metallic filaments (in this case often made of tungsten impregnated with thorium) give off streams of electrons (*see* Atoms; Electrons and Electronics). These electrons, carrying, as they do, *negative* charges of electricity, are strongly attracted by the *positive* charge produced on the plate of the tube by the "B" battery. The higher the voltage of the "B" battery, other things being equal, or the hotter the filament, the more electrons will flow. This stream of electrons acts as a conductor between filament and plate, much as if it were a wire bridging the space, and this completes what is called the plate circuit.

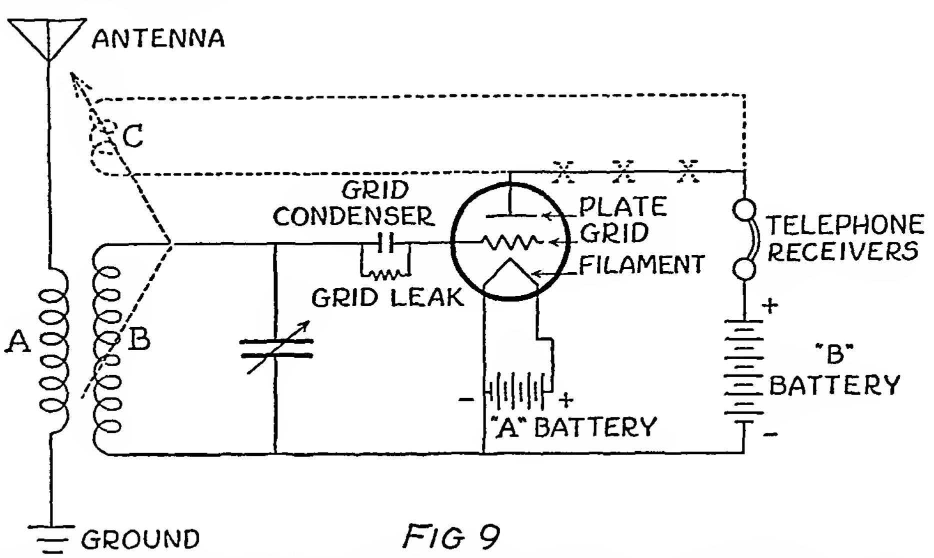


FIG 9

The operation of this one-tube receiving set is described in the text. Heating the filament sets up current in the plate circuit, running from the "B" battery, through the filament, plate, the wire marked with X's, and the telephone receivers. Incoming signals pass through the antenna circuit, consisting of the antenna, coil A and the ground, and are impressed as the text explains, upon the current in the plate circuit, by means of induction between coils A and B, and the grid circuit, consisting in part of the grid condenser and grid leak. The counterpart of each charge passing this way is considered as passing through the "minus" wire of the "A" battery leading to the filament. All these connections taken together form the "grid circuit," which is really a "charge circuit," incapable of carrying current from either battery because of its condensers. The antenna circuit is tuned by the variable condenser. The text explains the function of the grid leak and grid condenser, and how a tickler coil C may be used. When C is used, the wire marked with X's is omitted. In an actual set C is mounted within the inductive field of B, as indicated by the dotted arrow. The text tells how this circuit can be made regenerative or oscillatory.

The Vacuum Tube as an Amplifier

The current flowing through this circuit while the filament is lighted remains constant so long as the grid of the tube is electrically neutral. But now we will suppose that a train of modulated radio waves passes this receiving set, which has been tuned to resonance with them. At once a corresponding oscillating current is set up in the grid circuit shown in Fig. 9, and every fluctuation of this current produces corresponding changes in the electrical charges on the grid. These are called changes in "potential," that is, in the positive or negative relation of the grid to the filament or the plate.

Since the grid stands between the filament and the plate, it is evident that when this charge tends toward the positive side it will reinforce the positive attraction of the plate, increasing the flow of electrons from the filament to the plate and, therefore, also the flow of current in the plate circuit. When the grid tends to be negative, it will oppose the flow of electrons because charges of like sign repel each other and, therefore, decrease the current flow.

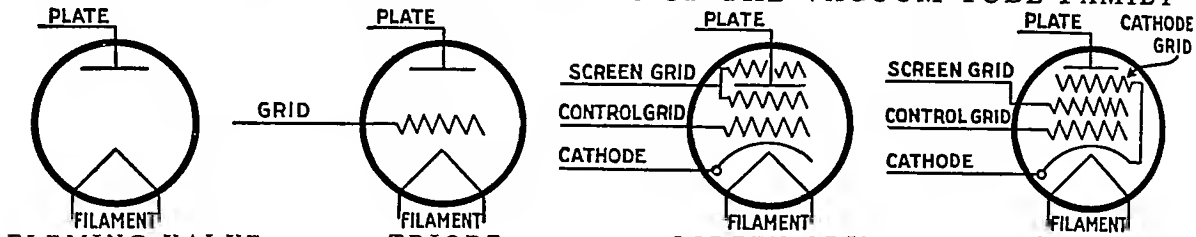
The important part of the whole process is this: Every little fluctuation in the *very weak* current oscillating in the grid circuit controls the relatively powerful direct current flowing in the plate circuit. Thus is accomplished what is called *amplification*. What was formerly a feeble signal becomes powerful.

It is obvious that this same process can be repeated by passing the once-amplified current from the first tube on to a second tube where it will be amplified again. This transfer is usually accomplished by "inductive coupling" (*see* Electricity) between a coil in the plate circuit of the first tube and a coil in the grid circuit of the second tube. This process of magnifying the incoming signal before it is detected is called *radio-frequency amplification*. It is seldom carried out through more than four successive tubes or "stages." (When coils from separate circuits adjoin each other end to end or side by side, a fluctuating current in the first coil will set up a similar current in the second coil by electromagnetic induction. Such an arrangement of coils is what is meant by "inductive coupling" or induction.)

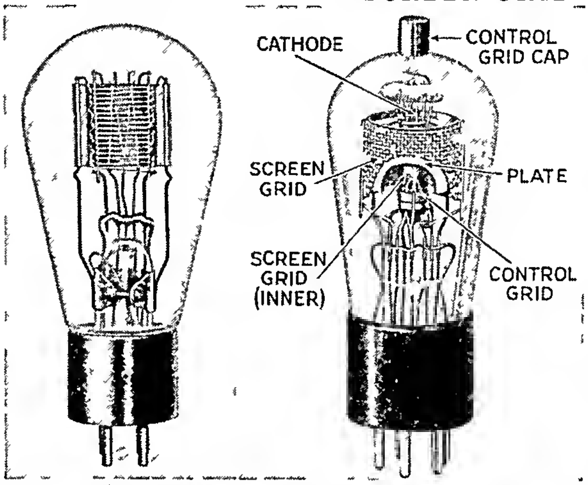
The Vacuum Tube as a Rectifier and Detector

This ability to amplify makes vacuum tubes valuable not only in radio, but in many other fields, such as long-distance telephony, where relays of vacuum tubes keep the current sustained so that speech is possible even over such distances as that between San Francisco and Paris. A second important property of vacuum tubes is their ability to *rectify* alternating currents—that is, to take an input of alternating current on the grid, and furnish a direct current to the plate circuit. This is accomplished by giving the grid a "negative bias," or negative charge. This can be done either by connecting the negative terminal of a small "C" battery to the grid, or by using a suitable condenser and high resistance (called the grid condenser and grid leak), which insure that negative electrons once on the grid can only leave slowly. The bias is so arranged that the negative grid charge is always greater than any positive charge which may be brought in upon the grid.

ANCESTORS AND PRESENT MEMBERS OF THE VACUUM TUBE FAMILY



FLEMING VALVE — TRIODE — SCREEN GRID — PENTODE



Vacuum tubes started with the Fleming valve at the upper left. The text explains how Lee De Forest added the grid, creating the triode or audion. A modern triode is shown immediately above at the left, with part of the plate broken away to show how the fencelike grid surrounds the M-shaped filament. Addition of a cathode gives the "screen grid," and of another grid, the "pentode." In these two tubes, the filament is simply a heater, and the cathode gives off the necessary electrodes. A screen grid tube is shown immediately above at the right.

Now picture what happens when an alternating current having first positive, then negative, potential, is impressed upon this negative charge. The positive charges diminish the negative grid charge, while the negative ones reinforce it. Thus the grid charge is alternately weakly negative, and strongly negative. These fluctuations are reflected in the plate circuit by greater or less strength in the direct current always flowing in that circuit. We say, therefore, that the alternating current has been rectified, although this is not strictly true, in the sense that a crystal rectifies an alternating current. What has happened is that an incoming alternating current has been used to produce variations in the strength of a direct current, corresponding exactly to the alternations of the first current. It is by this action that a tube "detects" incoming signals and tubes which perform this function in a set are called "detectors."

The Vacuum Tube as an Oscillator

The third way in which a vacuum tube can be used is as an *oscillator.* Let us imagine a tube connected with grid and plate circuits so balanced that the two are in virtually perfect resonance or tune with each other. A phenomenon called "feed-back" will take place, where the stronger plate circuit oscillations are picked up by the original grid circuit, greatly reinforcing the feeble oscillations already going on there. This, in turn, tends to pass more energy on the plate circuit, which again feeds back more powerfully to the grid, and so on, until each strengthens the other to the maximum point. Sometimes this feed-back takes place through the capacity existing between plate and grid, which acts like a tiny condenser inside the tube. Sometimes it is brought about more powerfully by a special "tickler" coil coupled by induction to the grid circuit coil, as indicated by the dotted lines in Fig. 9. This produces a circuit of the *regenerative* type, which is very sensitive and efficient.

When, however, this feed-back is carried too far, the tube goes into "self-oscillation," usually marked in a receiving set by howls and squeals. The oscillations are transmitted back to the antenna, where they proceed to send out their own independent train of radio waves, so that the set becomes a miniature broadcasting station, much to the annoyance of neighboring radio listeners, who hear those same howls and squeals in their own sets.

Undesirable as this self-oscillation may be in a receiver, it is the very principle employed by transmitting stations for generating carrier waves except that high-power tubes and heavy currents are used, with elaborate controls for insuring exact results.

The Superheterodyne Circuit

A small self-oscillating circuit is deliberately employed as a part of the *superheterodyne* system used in the majority of receivers today. This system is based on the fact that it is possible to mix two oscillating currents of different frequencies to produce a "beat" current whose frequency is equal to the difference between the two (*see* definition of beats under Sound). This is known as "heterodyning." We will suppose, for example, that the incoming signal has a frequency of 600 kilocycles. If the oscillator in the set is tuned to 400 kilocycles, the frequency of the resultant signal (otherwise unaltered) will be 200 kilocycles. This signal can then be fed into an *intermediate-frequency amplifier* permanently tuned at 200. Whatever the frequency of the incoming signal may be, the oscillator can be tuned with it to yield a 200-kilocycle beat, to which the rest of the set is resonant. One of the great advantages in this method is that amplification at moderate frequencies is much easier and more effective than at high frequencies.

"Audio-Frequency" and "Choking"

After a radio signal has passed through the detector tube, whether it underwent radio-frequency ampli-

fication before that or not, it still lacks the power to operate a loudspeaker. It must be amplified still further in its rectified state. For this purpose one or more stages of *audio-frequency amplification* are used, consisting of step-up transformers (*see* Transformer) and additional amplifying tubes. The point which distinguishes audio-frequency amplification from the radio-frequency type is the use of "choking" in the audio transformers. As the article on Electricity explains, the more inductance a coil has, the more slowly current is built up in it, and inductance can be increased in a transformer by adding more coils of wire or using an iron core. For audio-frequency amplification, a transformer is given so much inductance that by the time the rapidly changing potential of a radio-frequency current gets a current change started through the coil one way, the potential has changed in sign, and ceases to build up the newly started amplified current. Thus the amplified current "dies," so to speak, before it gets well started—or, in the customary term, it has been choked by the high inductance of the coil. The energy represented by these choked frequencies is dissipated through "by-pass" condensers, and only the audio-frequency fluctuations corresponding in frequency to sounds get through the coil. These are increased in amplitude, by both the rise in voltage due to the transformers and the use of more powerful currents in the plate circuits of the audio tubes, until they are strong enough to set up mechanical vibrations in the loudspeaker which reproduce the sounds.

So much for the essentials of transmission and reception. The following is a brief summary of the principal parts of radio circuits, showing how they may vary in form and use:

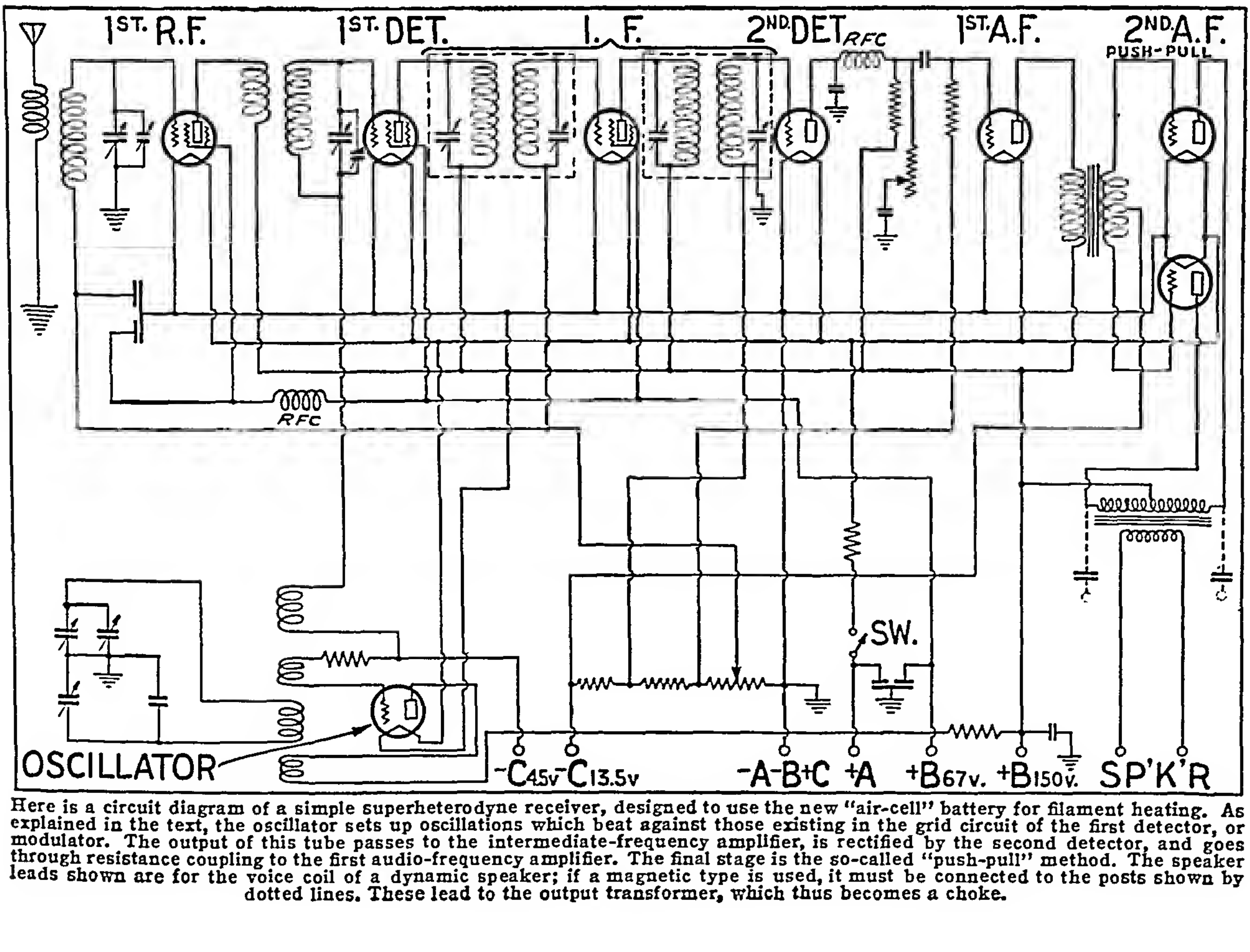
Antenna: Consists usually of several parallel wires for broadcast and long-wave transmission, and of a single wire for short-wave transmission and for reception. A "loop" antenna, consisting of one or more turns of wire around a frame, can be used for reception. It has strong "directional" properties, producing a maximum signal when the edge of the loop is turned toward the transmitting station, but little or no signal when the loop faces the incoming waves. Direction finders and radio compasses on ships and aircraft usually employ this principle (*see* Navigation).

Coils: Their size and number of turns help to determine the tuning of a circuit. They are also used in pairs as air-core transformers to transmit the radio-frequency current by induction from one stage of the circuit to the next.

Condensers: Fixed condensers are used chiefly where it is necessary to pass an oscillating current but to block off the direct plate or filament current. Variable condensers are used for tuning, in conjunction with coils.

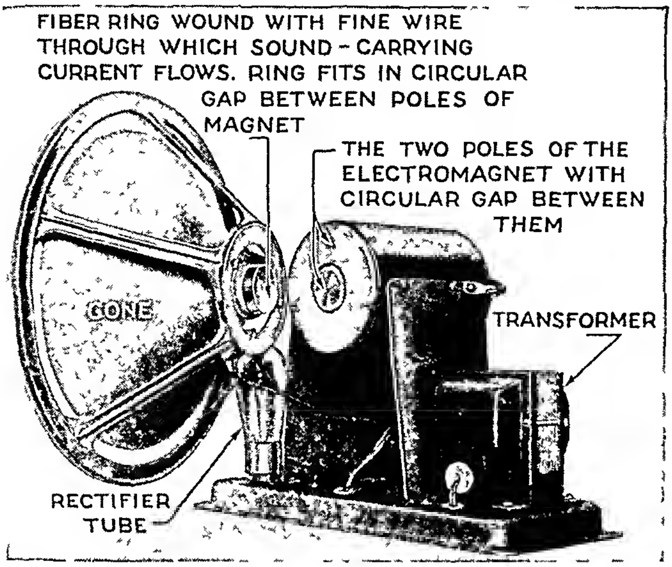
Vacuum Tubes: Besides the simple type described earlier, there is the "screen-grid" tube containing an extra grid which helps to prevent feed-back and so permits greater amplification without the danger of oscillation; the "pentode" tube with a third grid to help eliminate the crowding

CIRCUITS AND OPERATION OF A SUPERHETERODYNE



Here is a circuit diagram of a simple superheterodyne receiver, designed to use the new "air-cell" battery for filament heating. As explained in the text, the oscillator sets up oscillations which beat against those existing in the grid circuit of the first detector, or modulator. The output of this tube passes to the intermediate-frequency amplifier, is rectified by the second detector, and goes through resistance coupling to the first audio-frequency amplifier. The final stage is the so-called "push-pull" method. The speaker leads shown are for the voice coil of a dynamic speaker; if a magnetic type is used, it must be connected to the posts shown by dotted lines. These lead to the output transformer, which thus becomes a choke.

THE SECRET OF THE DYNAMIC SPEAKER



A dynamic speaker opened up to show its construction. The cone carries a ring wound with fine wire—the "voice coil"—which normally rests in a strong magnetic field in the circular gap between the poles of the electromagnet. When a fluctuating current passes in the voice coil, the coil vibrates to produce sound waves.

of electrons around the plate; and the "A.C." tube, the filament of which can be heated with alternating current. All of these are made in a wide variety of sizes.

Audio Transformers: Both the primary and secondary windings of an audio transformer consist of many turns of fine wire around an iron core, used in increasing inductance.

Batteries: Before the advent of receivers that are run by the house current, all sets used batteries. The "A" battery, usually of 6 volts, lights the filaments of the tubes; the "B" battery, ranging up to 180 volts or more, provides the plate currents; and the small "C" battery is used to regulate the negative bias of the grids of the tubes.

Loudspeakers: The early type of loudspeaker was nothing more than a large telephone-type receiver attached to the base of a megaphone horn. Later the horn was discarded, and the magnet, instead of acting on a diaphragm, worked on an armature mounted between its poles. The armature, in turn, transmitted its vibrations through a pin fastened to the center of a large cone. This is the principle of the so-called "magnetic speaker." The "dynamic" type of speaker contains a powerful electromagnet energized by an independent current. The current carrying the signals passes through a coil fastened to the cone. This coil is more or less strongly attracted by the electromagnet, depending upon the fluctuations of the signal current it carries, and so transmits its vibrations to the cone.

Shielding: In most modern receiving sets the various stages are separated from one another by metal shields to prevent undesired "coupling" or interaction between them. The shields may consist of individual containers for each tube or coil. The whole set may be protected by a metal case or by a metal lining in the wooden case so that it will not pick up so many stray signals or static from near-by house wiring, sparking motor commutators, or other sources.

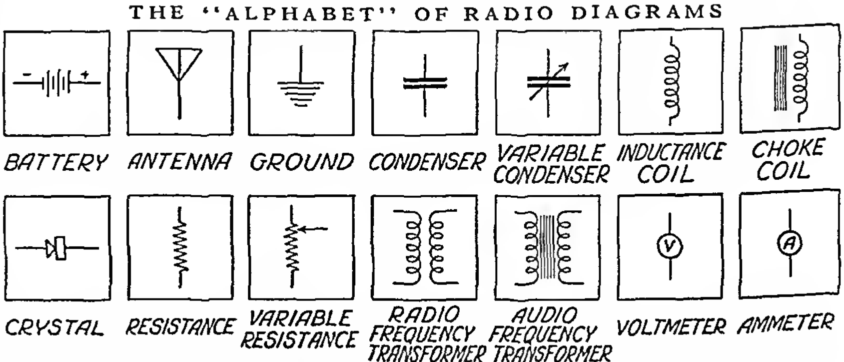
How far will radio messages carry? Signals can circle the earth and come right back to the starting place, completing the circle in about one-seventh of a second. The radio waves follow the curvature of the earth by "bouncing" between the ground and the *ionosphere*, a zone of ionized gas extending from about 60 to more than 700 miles up in the atmosphere. The lower part of this zone is called the Kennelly-Heaviside layer, after the two men who first suggested that it reflected radio waves (*see* Atmosphere). Long-range radio transmission is governed by changes in the height and density of the ionosphere. The National Bureau of Standards gathers data on these changes from stations all over the world. From these data, the Bureau can predict transmission conditions up to three months in advance.

Short Waves and Radio Beams

This reflection of waves makes long-distance *beam transmission* possible. As explained later, a special arrangement of antenna wires is used to concentrate the outgoing waves into a narrow cone. This cone is aimed in the desired direction and perhaps 15 degrees above horizontal. It strikes the reflecting layer several hundred miles away, and then it zigzags between earth and sky until it reaches the receiving station. Short waves are used for such work because they can be concentrated easily into a cone and because they can be reflected more accurately and with less cumbersome equipment. Messages can be sent on beams with as little as a hundredth of the energy that would be needed to reach the same distance by broadcasting in all directions; and short-wave messages can be sent all around the earth.

Short-wave radio also permits remote control of *robot* or automatically controlled ships and airplanes, which carry neither pilot nor crew. Receiving circuits, each sensitive to a certain definite signal, are connected to electric relays in the robot. Hence each relay responds to one signal only. When a signal is received it operates the proper relay, and the relay sets a motor to performing a desired operation of the craft's engine, steering mechanism, or other apparatus.

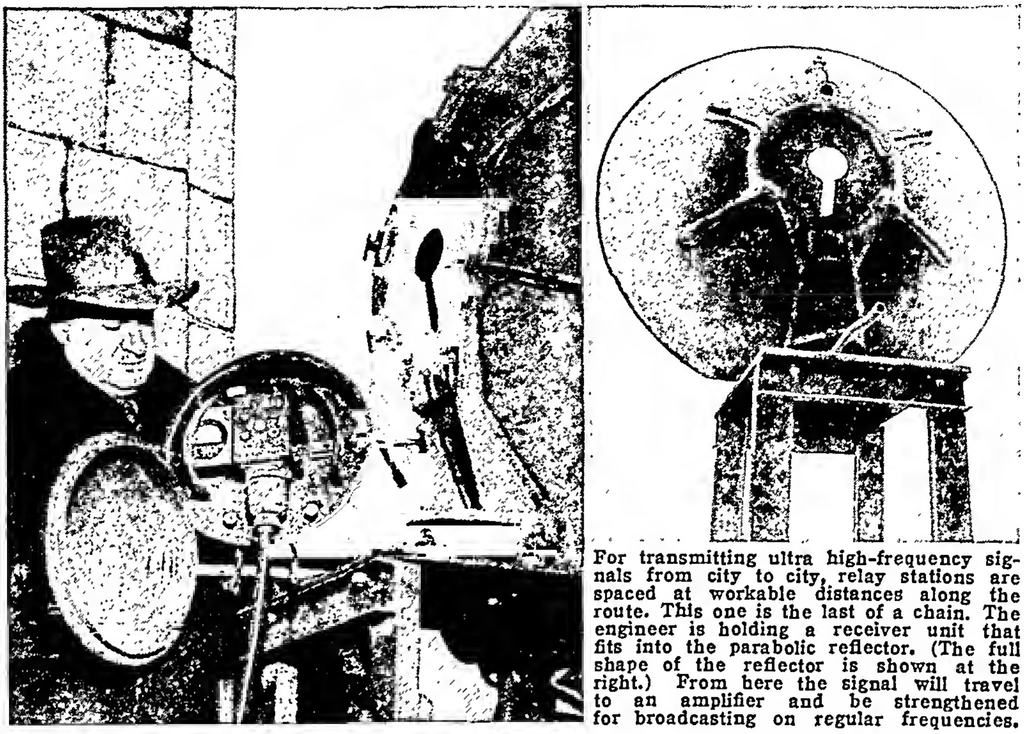
THE "ALPHABET" OF RADIO DIAGRAMS



The principal symbols used for the various parts of a radio circuit are shown here. The two upper right-hand symbols can also represent, respectively, a radio-frequency choke RFC and an audio-frequency choke AFC.

Much of the pioneer work in developing the use of short waves and beams was done by amateurs, many of them only boys. Before the first World War, these amateurs formed the American Radio Relay League. After the war they achieved communication between all the continents. In 1925 the amateurs of all important countries formed the International Amateur Radio Union. There are now about 80,000 licensed radio amateurs in the United States.

RELAYING ULTRA-HIGH FREQUENCIES ACROSS COUNTRY



For transmitting ultra high-frequency signals from city to city, relay stations are spaced at workable distances along the route. This one is the last of a chain. The engineer is holding a receiver unit that fits into the parabolic reflector. (The full shape of the reflector is shown at the right.) From here the signal will travel to an amplifier and be strengthened for broadcasting on regular frequencies.

Microwaves and Radar

When a wavelength is six meters or less (corresponding to a frequency of 50 million or more), new characteristics appear. Such waves, called *ultra short* (or *micro* when even shorter), penetrate the upper layers of the atmosphere instead of being reflected by them. Hence they can only be transmitted, like a beam of light, as far as a straight line will extend from the transmitter without encountering any obstacle. Beyond 20 miles or so, they go off into space, and reception on the ground is no longer possible. Likewise, ultra-short waves generated by the sun and other stars can pierce the atmospheric layers and be received on the earth by huge parabolic antennas.

These waves have a valuable compensating feature. They are reflected sharply from metals and various other solids. The discovery of this phenomenon after the first World War led to *radar*, or use of reflected microwaves to locate ships, airplanes, and other solid objects (*see* Radar).

Transmitting Ultra-High Frequencies

Regular radio broadcasts are carried from city to city over ordinary long-distance telephone wires. But television and other means of communication that use ultra high-frequency waves cannot travel over these wires. One method of transmitting these waves is by a radio-beam system. It relays the signal from station to station, spaced at maximum distances before the wave disappears beyond the curvature of the earth. One such beam can carry several television programs and radio programs and hundreds of telephone and telegraph messages as well. At these high frequencies the beam is not affected by static, lightning, or electrical interference.

Another method of transmission is by coaxial cable. Like the radio-beam relay system, the coaxial cable can simultaneously transmit many different ultra high-frequency waves. The cable, running between cities, is buried in a deep ditch. (*See also* Television.)

Other Uses for Short Waves

High-frequency short-wave circuits are very sensitive to change. Unless shielded they react, for example, to heat from a human body in the vicinity or to movement of a piece of metal. This reaction has been used for burglar alarms and in devices for locating land mines in wartime. Microwaves are reflected differently from various substances. Prospectors use these microwave beams in *geophysical soundings* to locate deep deposits of oil and ore.

The molecules of any object in a strongly oscillating electrical field move violently and generate heat, particularly in the parts that resist electrical flow. This principle is used in diathermy machines for medical heat treatment, in baking plastics to join layers of plywood, and in melting extremely thin layers of tin to coat metal. It is also used for cooking foods in the so-called "radar-range" stove. Here microwaves prepare foods in a few seconds or minutes, roasting or baking from the inside out.

Disturbances in Radio Reception

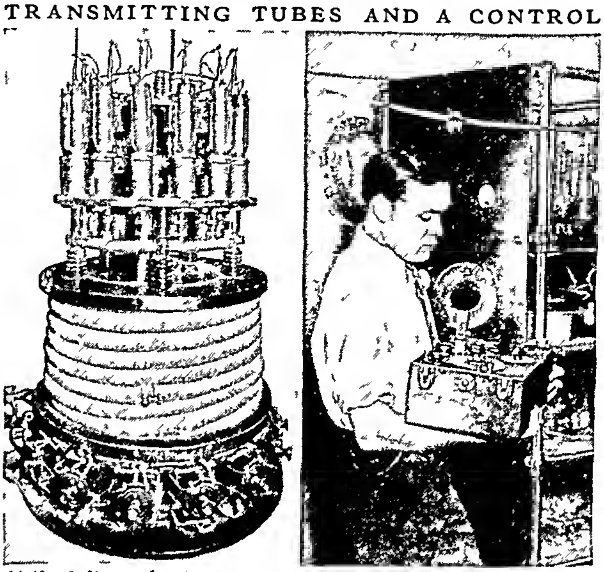
The chief obstacles to good radio reception are *fading*, *static*, and *interference*. Often a long-range broadcast will fade out and then return. Radio theory blames this on changes that are taking place in the reflecting layer of the ionosphere. Static is caused by electrical disturbances in the atmosphere or by sparking electric motors or X-ray apparatus operating near by. Frequency-modulation broadcasts, described on a later page, are not affected by static.

Interference between stations is diminished or eliminated by assigning to each station a definite wave-length sufficiently removed from that of stations using almost the same wave-length in the same territory, to prevent receivers with good selectivity from picking them both up at once.

The Piezo-Electric Quartz Crystal

Since all available radio channels are much overcrowded, if any broadcasting station strays from the exact frequency assigned to it, there is sure to be a heterodyne effect which makes itself audible in the receiver as a continuous squeal when one or the other of the interfering stations is tuned in. The better stations prevent such trouble by using the piezo-electric quartz crystal. The word *piezo*, derived from the Greek, means pressure; if a piece of quartz, ground with flat, parallel sides, is placed in a circuit, the voltage applied to it will set up oscillations which maintain a steady rate depending mainly upon the thickness of the quartz, its temperature, and the pressure applied to it. Oscillations of other frequencies are blocked, and only the correct frequency is emitted by the station.

TRANSMITTING TUBES AND A CONTROL



At the left is a bank of 15 huge water-cooled vacuums used in transatlantic telephony. The long hose carries double distilled water for cooling the jacketed tubes. The principles, however, are the same as those given in the text for ordinary "oscillating tubes." At the right, a station operator is holding a "wave-meter," with which he periodically tests the wave-length of the outgoing "carrier" to make sure it is correct.

Station Licensing

No radio transmitting is permitted in the United States except by stations and persons who hold licenses from the Federal Communications Commission. The license fixes the frequency, power, and the call letters which designate the station. In assigning frequencies, the Commission observes the allocations provided in the International Telecommunication Convention (Atlantic City, 1947) and the North American Interim Regional Broadcasting Agreement (Washington, D. C., 1946). Bands are reserved throughout the range of frequencies for governments, aviation, ship communication, the police, and for international broadcasting. The call signals of stations are also assigned by international agreement. Each nation is assigned letters or groups of letters for its exclusive use.

Commercial radio broadcasting uses frequencies between 0.55 and 1 6 megacycles Amateurs use the following frequencies (in megacycles): 1.8–2.0 (shared with loran), 3 5–4 0, 7.0–7.3, 14 0–14 4, 26 96–27.23, 28.0–29.7, 50–54, 144–148, 220–225, 420–450, 1215–1300, 2300–2450, 3300–3500, 5650–5925, 10,000–10,500, and 21,000–22,000 Other special radio-frequency users may share these bands with amateurs.

The first or first and second letters of a station's call signal must be the same as those assigned to that nation, to show the station's nationality. Thus the United States uses N for its naval stations, and K and W for regular broadcasting stations. Great Britain's national letters are G and M; Russia's, R and U. Countries which have relatively few stations do not need the many combinations that can be worked out from exclusive use of a letter. Hence these countries are assigned groups of three-letter combinations starting with the same first letter. Thus Spain is given the range EAA-EHZ, and Ireland has EIA-EJZ. If the number of stations increases enough to warrant more combinations, additional ranges are assigned; thus Germany, which had only D, was later also given EZA-EZZ.

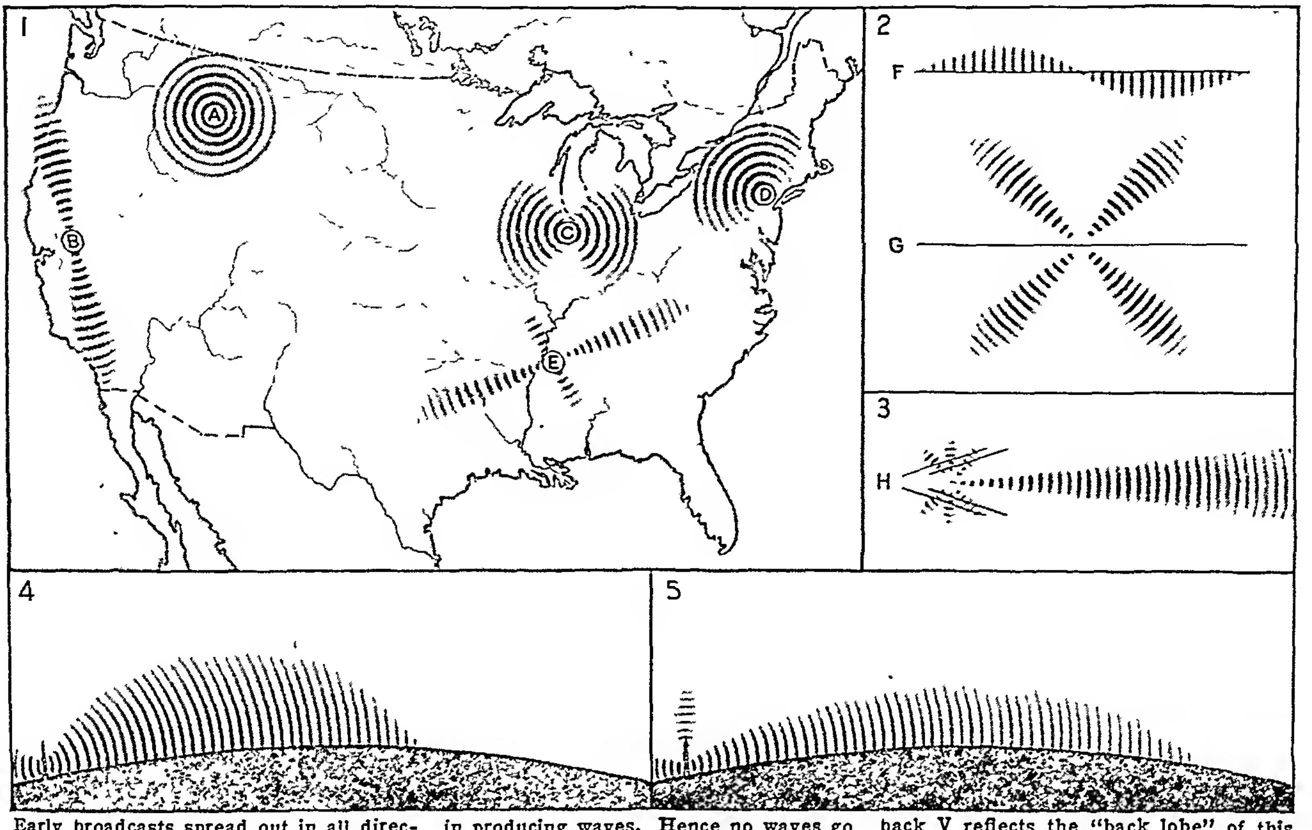
The development of radio circuits and of the vacuum tube has brought in its train countless related inventions and applications. Pictures are now sent through space (*see* Television). Amplifying units, consisting of vacuum tubes and transformers similar to the audio-frequency stages of radio receivers are used in electric phonographs to reproduce records with superior quality and volume (*see* Phonograph). The extreme sensitivity of the vacuum tube and of its cousin, the photoelectric cell, is used to control all sorts of automatic devices (*see* Photoelectric Devices). Microphones connected through amplifiers to clusters of powerful loud-speakers send the ordinary speaking voice of an orator resounding to the farthest corner of the largest auditoriums, or carry announcements across football and baseball fields Talking motion pictures were made possible by adaptations of radio circuits and allied devices (*see* Motion Pictures).

The discovery and development of radio is one of the most wonderful achievements of modern science As early as 1827, Savary showed that iron needles become magnetized if they are held near a spark discharge. In 1840 Joseph Henry succeeded in producing high-frequency oscillations and showed their effects over small distances. In the same year Samuel Morse, inventor of the telegraph, actually sent signals across a canal in Washington by stringing two parallel wires on the banks and using electromagnetic induction—not quite the same as radio, but close to it.

Invention and Development of Radio

When James Clerk Maxwell laid down his famous theory of electromagnetism between 1867 and 1873, he predicted the discovery of radio waves. This prediction was realized in 1888 by Heinrich Hertz, who, for the first time, actually demonstrated radio transmission by the spark method. He showed that when a heavy spark was discharged from a Leyden jar, a

HOW BEAMS AND BROADCASTS ARE SENT EXACTLY WHERE WANTED



Early broadcasts spread out in all directions, as shown at A in Fig. 1; but today radio engineers can control the direction and spread of the waves to produce almost any *field pattern* they want. Patterns B, C, and D in Fig. 1 avoid wasting energy over bodies of water, while pattern E is suitable for communication along an airway. The principle used for such *directed transmission* is illustrated in Fig. 2. The wire shown at F is an antenna, exactly one wave-length long. When a complete electrical pulse is in the wire, the two halves of the wire act against each other in producing waves. Hence no waves go out at right angles to the wire nor off the ends. The field pattern of such an antenna is shown at G, with the waves going out at oblique angles. Listeners receive signals from whichever end of the wire is nearer to them. By arranging several antennae to interfere with one another in some directions, but to reinforce one another in other directions, various patterns are obtained. For example, for beam transmission in one direction only, two open V's can be used, as in Fig. 3. The front V creates a narrow two-way beam. The back V reflects the "back lobe" of this beam, and thereby sends all the energy in the desired direction. Only small short-range lobes go out sideways. Figures 4 and 5 show some of the vertical effects obtained by standing an antenna up on end. In Fig. 4, an antenna 1/4th of a wave long is sending energy high into the air. In Fig. 5, a 5/8th-length antenna is sending a flat wave along the ground, and also is sending out a small vertical "sky loop." Strong sky loops of this sort are used to indicate the exact position of airports to planes flying overhead.

corresponding small spark leaped across a gap in a loop of wire 15 feet away. He proved by other experiments that the waves could be reflected and refracted like light waves. Because of Hertz's pioneer work, radio waves are often called *Hertzian waves.*

In 1895 a young Italian, Guglielmo Marconi, began developing Hertz's discoveries into a method for communication at sea. On June 3, 1898, he transmitted the first paid radiogram from the Isle of Wight in England, and on Dec. 12, 1901, he sent the first signals across the Atlantic. On Jan. 23, 1909, the value of radio was strikingly demonstrated when aid was summoned by CQD (now SOS) signals from the steamer *Republic*, after she had been rammed by the *Florida* near Nantucket. (*See also* Marconi, Guglielmo.)

The Slow Growth of Radio Telephony

As early as 1883 Edison had noticed that the filament of his incandescent lamp gave off electrified particles. This "Edison effect" was electronic emission, the basis of radio-tube action; but Edison did not see the importance of his discovery. Not until 1904, when J. A. Fleming produced his vacuum tube with two electrodes—the filament and the plate—was this principle applied to radio. In 1906 Lee De Forest introduced a grid between filament and plate, and produced what he called an "audion." This was the parent of the modern radio tube.

De Forest's audion was found to be the most suitable device for placing sound on the air, and radio telephony developed steadily thereafter. In 1914 E. H. Armstrong produced the regenerative circuit, and in 1916 De Forest broadcast music.

On Oct. 27, 1920, station KDKA at Pittsburgh obtained a license, and on November 2 it broadcast the 1920 election returns. This feat popularized broadcasting, and stations sprang up everywhere. In 1923 Louis A. Hazeltine patented the neutrodyne circuit, and in the same year broadcasts were heard across the Atlantic.

Beams and Field Patterns

A striking advance was *directed transmission.* Marconi led in this work by producing a radio beam in 1922. Within a few years R. M. Foster, G. C. Southworth, and others had developed the field-pattern methods shown in the diagram above, and broadcasting could be adjusted accurately to the areas served.

Similar methods provided radio beams for guiding airplanes.

"All-electric" receiving sets were developed in 1926. The term means a set that can be operated on any lighting circuit. For alternating circuits, the set "rectifies" the current by giving both halves of the cycle the same direction, then passes the current through choke coils and condensers to smooth out the pulsations and create a direct current of uniform strength.

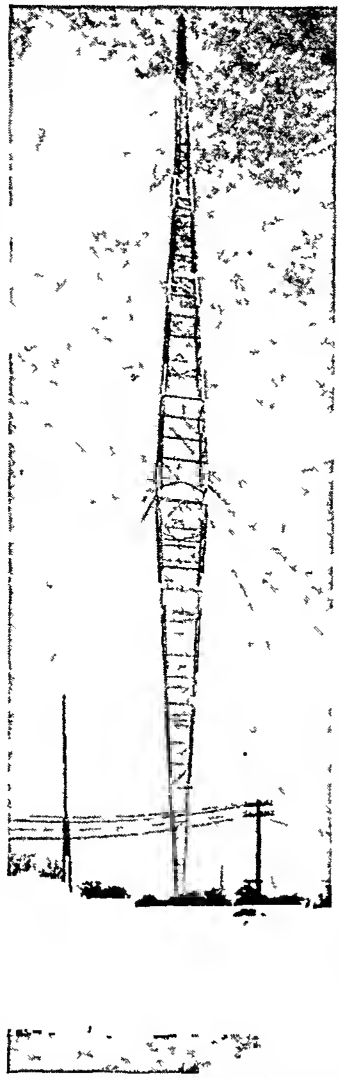
Nearly every American home has at least one radio set today. In addition there are millions more in automobiles and in hotels and other public places. Portable sets add more millions to the total. Television has captured many listeners from the evening audience, but people continue to make wide use of their radios at other times, especially as a pleasant accompaniment to such tasks as housework or automobile driving. Radio holds its own in such presentations as news and music broadcasts.

Vocational Opportunities in Radio

From the career standpoint, radio has two great fields of activity—direct communication and broadcasting. The communication work includes marine radio, airway control and communication, radio telephony, and similar activities. Broadcasting includes entertainment with commercial programs and educational programs.

Within each of these fields there are opportunities for employment in manufacturing and design, operating, and business management. Broadcasting also offers employment to "talent"—performers, musicians, and announcers, as well as producers, directors and writers. The technical aspects of radio offer opportunity, just as does any manufacturing and public-service industry, to those who "grow up in the business," by working in the shop or the office. Operators in communication service and operators of broadcasting stations are licensed by the government after passing examinations.

TYPICAL RADIATOR



This mast antenna or radiator is of the type used to broadcast in all directions. Its frame is 550 feet high and weighs 130 tons.

To attain the higher positions in manufacturing and operating, a good education in electrical engineering, with emphasis on radio, is almost indispensable. Many universities and some high schools now give instruction in the various branches of radio. They offer courses in radio engineering, acting, writing, and the business aspects of radio, such as time-selling and station management.

Opportunities for "Radio Talent"

Employment in the "talent" field has the same attractions, risks, and requirements as work on the stage and in motion-picture studios. To achieve a successful career, one should have exceptional talent and good training as a performer. The demands are so exacting, and the work is so strenuous, that one who has only average ability seldom finds a career.

Talent and Training Needed

The larger networks maintain announcer schools for those whose voices, diction, and general qualifications seem suited to microphone work. Actors must be familiar with microphone technique; they must know how to place their voices and how to read from script If they are accepted, they must expect many hours of rehearsal Some entertainers receive large salaries, but most get little pay for small and occasional parts Often, too, employment is short-lived, since many programs are discontinued after a few weeks

Like the theater and the motion-picture industry, radio broadcasting is an unusually intense business. With its long hours and its many disappointments, it calls for clear thinking and the ability to work in a spirit of cheerful and patient cooperation. Script writing and program planning require abilities similar to those needed in advertising. They also require special knowledge of both the powers and the limitations of broadcasting, which has to entertain, teach, and persuade by sound alone. (*See also* Advertising.)

How Radio Programs Are Broadcast

SUPPOSE we are listening to a radio program of music and entertainment. Suddenly the program stops, and a voice announces: "This is station XYZ. We interrupt our program to announce that the steamship *Gloria* is sinking, 50 miles east of Newfoundland, and requests immediate aid. Further details will follow as we receive them." Then the program continues, while we think of the grim scene out in the North Atlantic—the sinking vessel, lashed by a savage gale, and other ships hundreds of miles away plowing to the rescue, with all the power of their boilers and engines

This incident illustrates the modern miracle of radio broadcasting. It shows us the variety of service, whereby people throughout the nation can sit comfortably at home and hear a world-famous orchestra playing in New York City, or enjoy a performance by

HOW FREQUENCY MODULATION DEFEATS STATIC

BETWEEN 1935 and 1940 a new method for eliminating static and achieving high fidelity was sufficiently perfected to be applied in commercial broadcasting. This method, developed by Edwin H. Armstrong, inventor of the regenerative circuit, is called *frequency modulation* (F.M.).

Until this method was developed, static gave trouble because thunderstorms and certain types of electric equipment emit waves similar to those used in broadcasting. Thus the static waves could not be entirely filtered out by any conceivable device. Frequency modulation uses waves utterly unlike those caused by static. A receiver which is sensitive to these waves does not respond to static.

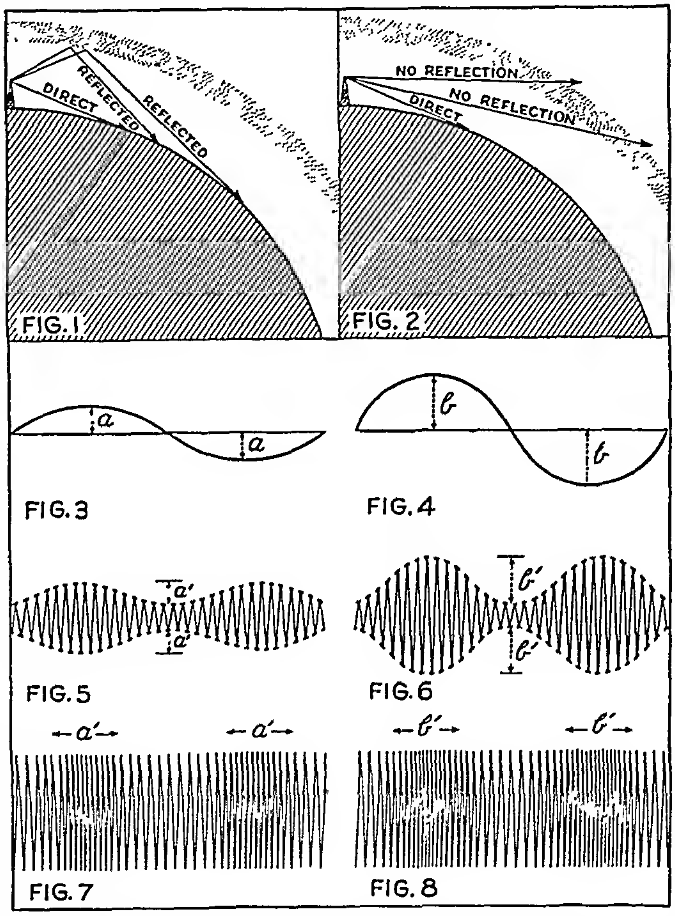
High fidelity in tone is achieved, as explained below, by using a range of frequencies as great as that of the tones themselves. Older methods blurred many of the finer tonal qualities, because they transmitted tones by modulating the strength or amplitude of carrier waves.

One drawback of frequency modulation is the limited range of the extremely short waves used. As explained on a previous page, and as shown in Fig. 1, the comparatively long waves used in amplitude modulation can follow the curve of the earth's surface, because they are reflected from the Kennelly-Heaviside layer.

Waves as short as those used for frequency modulation do not reflect from this layer. The difference is like that between little waves and big ones when they strike a rough breakwater. The little ones get broken up by the irregularities of the breakwater surface, while the big ones are reflected from the surface as a whole. When the extremely short radio waves have traveled far enough from the station to be above the surface of the earth (Fig. 2), the station cannot be heard. Their maximum range is between 50 and 100 miles.

This means that, to cover a wide area, there must be many transmitters at distances varying between 50 and 100 miles. Since the full range of wave frequencies required for frequency modulation cannot be carried over the ordinary network wires, programs must be sent to more distant stations by coaxial cables or some similar means.

Special receivers are necessary to reproduce programs broadcast by frequency modulation. Manufacturers meet this problem by offering sets equipped to receive both the older and the newer type of broadcasting. The Federal Communications Commission expects to let public preference, as shown over a number of years, determine the licensing of each type of broadcasting. The greatest conflict, however, will be with television, since it uses the same wave bands as those employed for frequency modulation.



These diagrams illustrate the principal differences between broadcasting by frequency modulation and the older method of broadcasting. The details are explained in the text.

Frequency modulation can be explained readily by comparing it with the older method described on a previous page. This older method, called *amplitude* modulation, keeps a constant frequency and wave length in the carrier wave, but varies the strength, or amplitude, of each vibration, according to the loudness of the sound being sent. For example, in Figs. 3 and 4 the wavy lines represent respectively a weak tone and a strong one, with strengths shown by amplitudes *a* and *b*. In Figs. 5 and 6 these amplitudes are shown impressed (*a'* and *b'*) upon a carrier wave.

Figs. 5 and 6 show that the frequency, indicated by the spacing of the zigzag line, remains unchanged. Only the amplitude, or width of swing, varies with the intensity of the tone.

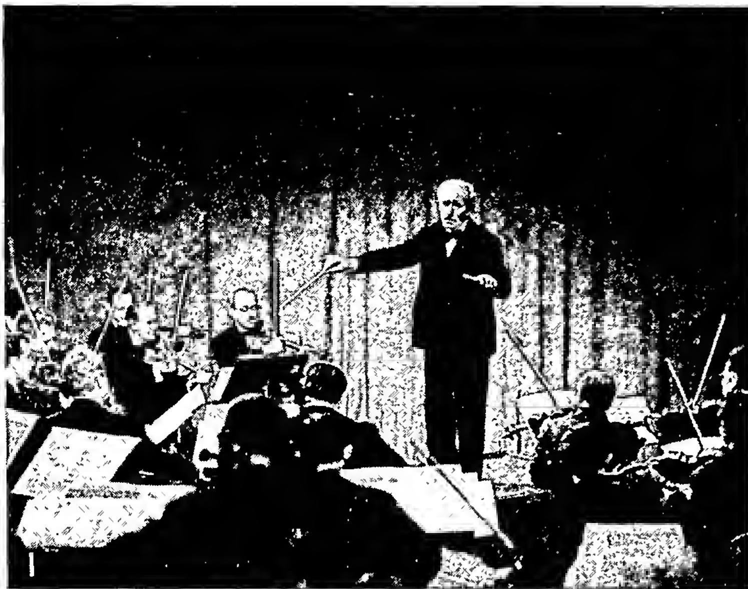
In frequency modulation, the frequency varies with the loudness, as shown in Figs. 7 and 8, while the amplitude remains the same. In Fig. 7 the same changes in sound strength shown in Fig. 3 are transmitted by two bursts (*a'*) of higher frequency, corresponding to amplitude (*a*). The louder sounds of Fig. 4 are transmitted, as shown in Fig. 8, by bursts (*b'*) of still higher frequency.

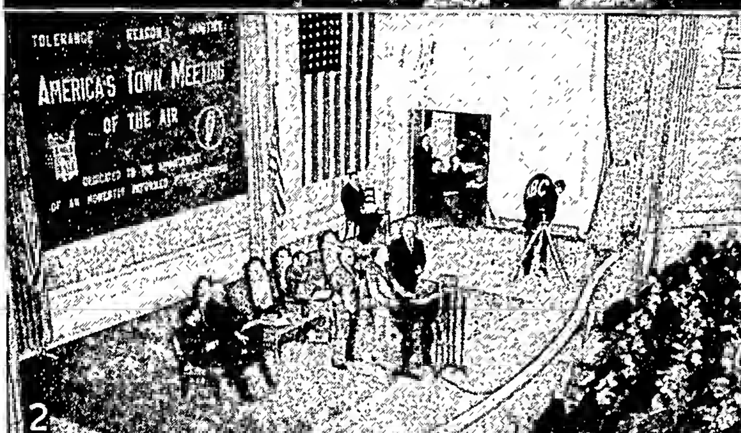
Thus the diagrams show us the wave changes by which each type of broadcasting transmits variations in the *loudness* of sounds. Variations of *pitch* in each case depend upon the number of times per second that the changes take place. In the older type of broadcasting a sound of higher pitch produces a greater number of changes per second in the *amplitude* of the carrier wave. In the newer type it produces a greater number of changes per second in the *frequencies* of the carrier wave band.

Electrical Principle of Frequency Modulation

An earlier section in this article explains that the frequency of the oscillations in a radio circuit depends on two factors—the inductance of the circuit and its capacity. To produce the frequency changes required in the newer methods of broadcasting, one or the other of these factors must be made sensitive enough to undergo changes in response to sound waves. Capacity, which depends on condensers, is more responsive to control than inductance, which depends upon coils. Thus the frequency modulation transmitters operate through changes of capacity in their circuits.

One way to accomplish this is to make the diaphragm of a microphone act as one plate of a condenser in the radio circuit. Thus every change in sound that strikes the diaphragm varies the capacity of the sending circuit and thereby changes the frequency of the outgoing signal. This principle is reversed in the receiving set.

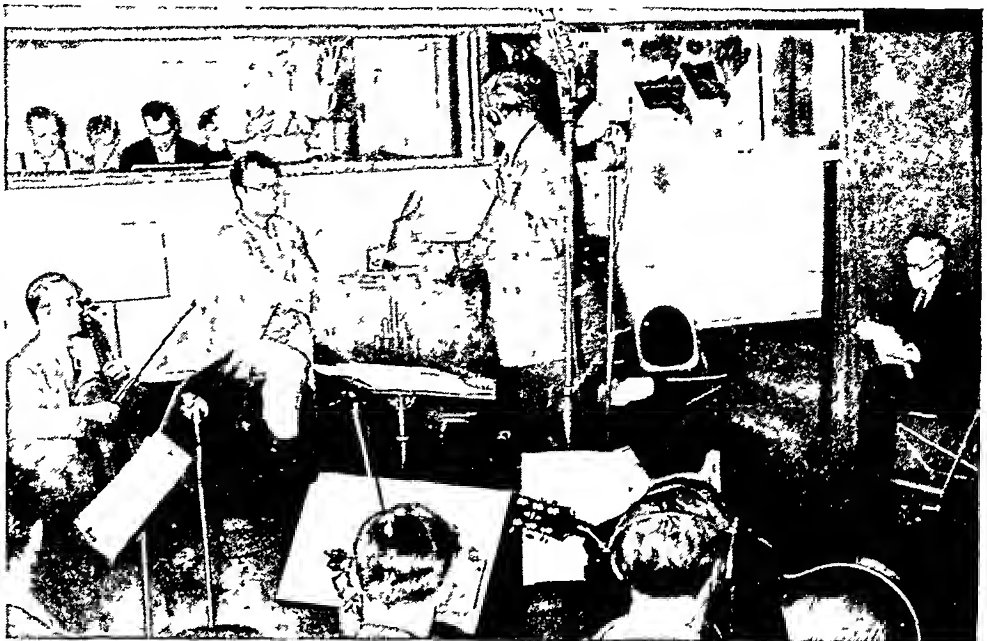




Success of programs such as these shows how eager people are to gain knowledge by radio. 1. Conductor Arturo Toscanini leads a symphony orchestra in a radio concert, one of many heard throughout the country over nationwide networks. 2 and 3. Here we see one of the widely followed "Town Meetings of the Air," with noted speakers debating a question of the day, and a microphone set to catch questions from the audience. In the close-np picture, one dehater ponders his answer to a point made by his opponent. 4. Three University of Chicago professors conduct a "Round Tahle" discussion. 5. The "American School of the Air" broadcasts from the American Museum of Natural History, New York City. The picture shows school pupils participating. 6. A Russian-speaking State Department group broadcasts a "Voice of America" educational program beamed toward the Soviet Union.

Hollywood stars, and also hear the latest news as it occurs. A talk by the president of the United States, by the head of a great industry, or by a labor leader demonstrates how the voice of one man can instantly reach millions of people. While housewives are busy with their tasks, they can listen to talks about new recipes, new foods, and household helps. People in isolated communities and men at lonely posts can keep in touch with the world. In a few seconds, the police in several states can be notified to watch for wanted criminals. Warnings can be given of storms and floods.

CLOSE-UP VIEW OF A STUDIO BROADCAST



The orchestra conductor near the microphone is catching a signal from the director in the control room. The director holds up three fingers, meaning, "You have three beats of the time clock left." In the right-hand control room, the actors who are to follow await their cue.

How are these radio broadcasts sent out? Let us visit a large broadcasting station and watch a program in progress.

Inside a Broadcasting Studio

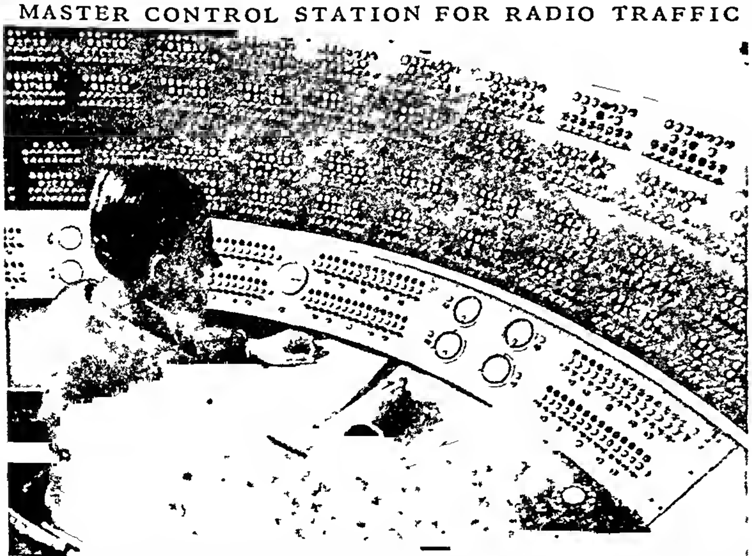
Large stations have many studios, from small rooms for single speakers, to great audience halls large enough for an orchestra and several hundred spectators. In all the studios, the walls and the ceiling are covered with sound-absorbing material to prevent echoes.

Shortly before the broadcast starts, the announcer warns us that the microphones pick up every sound, and asks us not to talk during the performance. He also asks us to stop applauding at a signal from him, to permit the program to continue. Then a red signal light flashes on, warning us that our studio is "on the air." The announcer reads his introduction for the program, and the performance begins.

Then we look through a sound-proof window into the adjoining control room. There we see an engineer, who sits before a control board with many instruments, and a producer, who directs the broadcast. The producer can watch the performance through the window, but all he hears is the sound that comes through a loud-speaker.

When the music of the program starts, we may notice a tendency to blare. Instantly the engineer twists a knob on his control board, until his sound meter reads approximately 30 decibels. This, we are told, is the favorable volume, or measure of loudness, for music, while about 20 decibels is correct for voice volume.

MASTER CONTROL STATION FOR RADIO TRAFFIC



More than a thousand wire terminals enter and leave this great switchboard and signal station. It is one of three in Radio City where studio and station hook-ups are made and nationwide schedules are distributed.

Presently the producer gives a hand signal to the performers to speed up. He must bring the program to an end at exactly the right time, "on the head." He times the performance from a script which shows the second at which key parts of the program should be reached. If the performers fall behind or get ahead of schedule, the producer signals them to go faster or slower.

Programs from Near and Far

In another studio, performers are getting ready for the program which is to follow the one we are watching. In the master control room, an operator is ready to switch to this other studio at the proper second. Meanwhile he watches his instruments to see that our program is being properly sent out to the transmitting plant, where it is broadcast into space. This station is usually

several miles away in the country, to escape interference from steel-framed buildings and to avoid electrical disturbances from city circuits. The program is carried to it over wires leased from the telephone company.

The master operator also switches in all network programs. Usually these programs are sent from wherever they are being performed over leased wires to the local stations that are members of the network. Each station then converts the incoming program to its own wave-length and broadcasts it. If storms or floods interrupt the wire service, the network companies use a short-wave radio to bridge the gaps. Short-wave hookups are always used for transatlantic programs and for broadcasts from airplanes or ships at sea.

Painstaking Preparation for Broadcasting

Behind the smooth flow of the broadcasts that we hear on our radios is an amazing amount of preparation. Most programs are planned well in advance by the *program departments* of the stations and of advertising agencies. Highly trained writers in *continuity departments* prepare the scripts. Actors, musicians, and others rehearse each program hour after hour until it fits the allotted time. The *publicity departments* send out notices about the programs for the radio pages of newspapers.

A large station's programs may run continuously throughout the 24 hours. In the morning comes news and lively music. Between breakfast and noon, most stations offer household hints and dramatic serial stories. Then come music, drama, educational features, and broadcasts of athletic events. Children's programs are given between four and six o'clock in the afternoon. The hours thereafter are reserved for the most important programs, because the greatest number of people are listening then. Some programs are presented for both radio and television audiences.

Sound Effects and Electrical Transcriptions

In the early days of broadcasting, *sound effects*, such as the noises of storms and airplane motors, were produced by devices operated in the studio during the performance. Today many such effects are obtained from phonograph records previously prepared. This so-called "electrical transcription" produces better effects, since the producer can try for the desired effect again and again until a perfect recording is obtained. It is also cheaper, since the records can be rented to stations for much less than it would cost the station to produce the effect in its own studio.

Complete programs, as well as sound effects, are transcribed for rental to small stations. Transcriptions also overcome the difficulty caused by differences in time from coast to coast. Nine o'clock at night, for example, is a fine time for reaching the East. Listeners in the Middle West could hear the program at eight o'clock, which is also good. But the Rocky Mountain States would hear it at the less favorable hour of seven, and the Pacific coast at six. Therefore transcribed programs are prepared for later use by western stations. To prevent deception, however, the law requires that such performances be announced as transcribed. "Live" performances are usually transcribed even if the transcription is not to be used. The record permits a "play back" if controversy or lawsuits arise from the performance. Advertisers can study their past programs and important speeches can be permanently preserved.

Advertising Supports American Broadcasting

The total cost of broadcasting on the tremendous scale prevalent in the United States is enormous. How can it be made to pay for itself?

Radio manufacturers started broadcasting soon after the end of the first World War to stimulate the sale of receiving sets. Some newspapers and other enterprises also established stations to advertise themselves. When the novelty wore off, stations had to give better and more expensive programs to hold their listeners. In 1924 stations began to seek additional revenue by selling time to advertisers. Advertisers found this profitable, and soon they were spending millions of dollars a year to buy "time on the air."

Charges are based on the potential size of the audience, which depends on the range of the station or network of stations and the time of day. Early morning and late evening hours are the cheapest. The hours from about 6:00 to 10:00 p.m. are the most expensive.

With the continuing growth of television, costs for radio time and talent were reduced to meet the competition of the newer medium. Advertisers found that radio still kept its audience during daylight and late evening hours; and they sponsored programs during these times as before. But a steady number diverted their important 6:00 to 10:00 P.M. evening programs to television.

The Growth of Networks

Networks, or combinations of stations giving the same programs, sprang up when many small stations found that they could not afford to provide programs good enough to hold listeners. So they arranged connections by wire with large stations, and the group of interconnected stations formed a "regional network." The managers of the network then sold time over the entire system to advertisers.

The regional networks pointed the way to "national hookups," or *coast-to-coast chains*. In 1926 the National Broadcasting Company was formed, and soon had two chains, the Red Network and the Blue Network. Besides using their own outlets, the chains hooked up with local stations to increase advertising coverage. In 1927 the United Independent Broadcasters, Inc., later the Columbia Broadcasting System, was formed. In 1934 the Mutual Broadcasting Company was organized. In 1942 the two chains of the National Broadcasting Company were separated at the request of the Federal Communications Commission, and the independent Blue Network Company, Inc., was formed. The latter changed its name in 1945 to American Broadcasting Company.

Foreign Broadcasting Systems

Because the radio offers enormous possibilities for spreading propaganda, broadcasting in foreign countries has been either conducted or rigidly controlled

WHERE THE WRONG THING SOUNDS RIGHT

Few noises sound like themselves over the radio. Besides, many of the noise-makers, like cows or locomotives, could not conveniently be brought into a studio. Here are some of the "sound effects" commonly used in radio plays and news broadcasts.

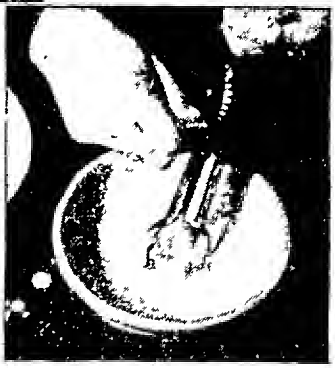
A crackling fire may be only crushed cellophane.

Pegs striking a table top imitate a marching army.

Hoofs on a hard road are clacking coconut shells.

Something moving in the bushes is twisted straw.

The hero floors the villain by punching a rubber sponge.



A rare exception—an egg-beater can imitate itself.

by the governments. In some countries it has been financed by collecting license fees from the owners of receiving sets, and no time has been sold to advertisers.

In England most broadcasting is done by the British Broadcasting Corporation (BBC), though a few unimportant privately-owned broadcasting systems are allowed to operate. The Corporation frankly serves the interests of the government, but it also tries to meet the preferences of different "interest groups." It takes no commercial advertising. Programs are transcribed to be broadcast to the dominions and the colonies at suitable hours.

Before and during the second World War, Germany and Italy used government-controlled broadcasting to spreadpropaganda, both abroad and at home. In both countries, special attention was given to news and entertainment in the languages of the countries at which the program was directed. Ownership and use of the receiving sets were strictly controlled. Listening to foreign broadcasts was forbidden, and listening to certain home programs was compulsory. Japan followed the same controlled nationalistic policy.

The Soviet government of Russia has always rigidly controlled broadcasting through official organizations. Educational and propaganda programs are emphasized. Owners of receiving sets pay a fee, but most of the people hear the programs from loudspeakers in schools, halls, and other public places.

Social Problems Created by Radio

LONG before broadcasting came into existence, all important governments had been compelled to impose certain controls on radio, if only to prevent hopeless confusion on the air. In the United States, for example, the Radio Act of 1912 required all stations to obtain a federal license from the Department of Commerce, largely to prevent interference with stations which maintained communication at sea. At first the Department granted licenses freely for frequencies not used for marine communication. By 1924, however, there were more than a thousand stations and all available frequencies were in use. Many stations were increasing their power, and so were interfering with distant stations on the same frequency. Something had to be done, or broadcasting would soon be a chaotic jumble of competing programs.

The Department of Commerce then refused to grant more broadcasting licenses, and in 1927 Congress established a Federal Radio Commission, with broad regulating powers. In 1934 its duties were taken over by the Federal Communications Commission.

Under this control the country is divided into seven radio regions, and commercial broadcast stations are grouped into three classes. *Clear-channel* stations have exclusive use of their frequencies and operate with not less than five kilowatts of power and no more than 50. *Regional* stations use between 500 and 5,000 watts. *Local* stations use between 100 and 250 watts. Stations are divided as to whether they make unlimited or part-time use of their facilities. The FCC assigns frequencies to all radio channel users, except to the Federal government itself. Frequencies for federal use are assigned by the president.

The Question of Censorship

Out of this federal licensing system has come the question of government censorship of programs. A de-

gree of indirect censorship was inevitable, because the number of stations wanting licenses was greater than the number of available frequencies. In granting licenses the commissioners therefore based their decisions largely on the *public interest.* This meant, not only the interest taken by listeners in the different stations, but also the Commission's opinion of how well the public interest was being served by each station. To apply this principle, the Commission had to decide what constituted high quality and valuable service. This amounted to indirect censorship, since the Commission gives licenses for only three years and can shut down any station after that time.

Pros and Cons of Government Control

Broadcasting stations object to this control. They point out that they have spent large sums for equipment, to train a staff of workers, and to win listeners. This investment, they say, should give them a property right in their licenses. They hold that the government should be entitled to limit or revoke a license only for offenses against law, order, or decency.

The Commission claims that such a rule would "freeze" progress, because the physical nature of radio broadcasting sets it apart from other forms of communication. Any number of newspapers or speakers in public halls can compete for public attention without interfering physically with each other. Competing telegraph and telephone lines can be strung along the same route. But only one radio station in a region can use a frequency at one time. If a station makes poor use of its right, the public cannot afford to wait until the station is forced out of operation by loss of listeners. The Commission should have the right to give the frequency to someone who will make better use of it.

War Time Censorship

Immediately after the United States entered the second World War, radio was subjected to the regulations of the Office of Censorship. Programs in which members of the studio audience take part were subject to strict scrutiny to prevent information being given to the enemy under cover of seemingly innocent remarks. Amateur stations were banned, except for official services, and the nation-wide monitoring system was perfected to detect secret sending apparatus. These restrictions were lifted after the war.

Education on the Radio

From the beginning, far-sighted men foresaw the vast possibilities of radio as an aid in spreading knowledge and promoting culture. Within a year after KDKA started commercial broadcasting, many colleges and institutions had started to give educational programs.

Some of these programs offered crop reports, information about household management, and talks on political, social, and business problems. Others offered addresses by noted men and women, classics of literature, drama, and music, and other material of general educational and cultural value. Classes were organized in definite studies. Some of these classes were home groups. Others were set up in schools, by having pupils throughout a school system listen to broadcast lessons.

Some of these efforts proved highly successful; others did not. To be effective, an educational program, like a commercial program, must be prepared by skilled writers and presented by skilled speakers. Most educational projects could not afford to hire a staff of such workers; and often those in charge of the programs failed to realize the kind and amount of preparation needed.

Educational versus Commercial Broadcasting

Many leaders in education urged that commercial broadcasting companies should give free time on the air to educational programs. They argued that no company had a right to use its monopoly entirely for its own profit, by selling all the good hours to advertisers. They also censured the commercial companies for putting on some programs which they considered to be trashy, sensational, and degrading to public taste.

The commercial broadcasters replied that before a station could help in educational work it had to earn money enough to keep going. If those who were interested in promoting education and culture could not provide the money needed, the station had to get it from advertisers. To do this, they had to attract listeners, and they could not afford to load their programs with dull lectures and other material of limited appeal. Further, they called attention to the educational and cultural value of their sustaining programs of symphony concerts, grand opera, debates, and round-table discussions by noted speakers. They pointed to the fine quality of many advertising programs. They said that schools reported greatly increased interest in good speech, because of the example set by station announcers and others. Broadcasts of fine symphonic music had led to the establishment of good orchestras in many cities and had raised the standards of musical taste throughout the nation.

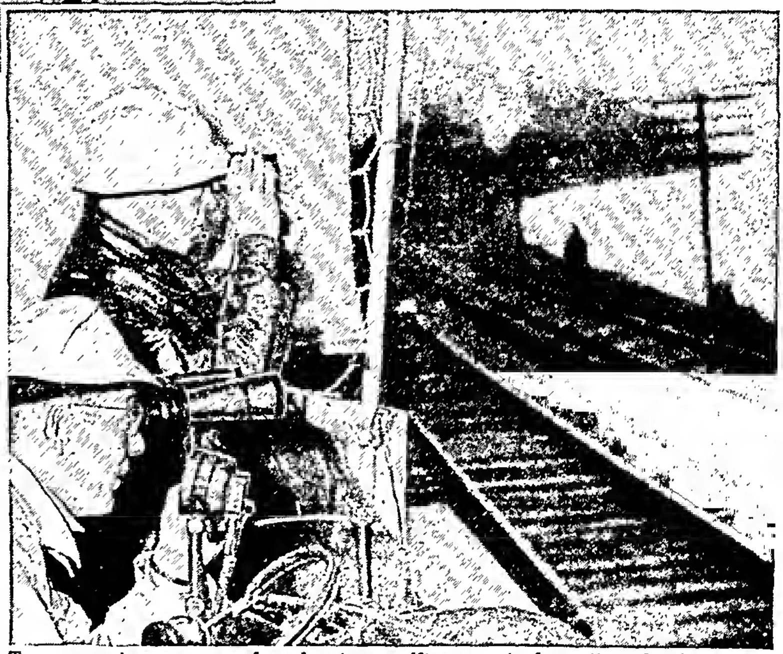
Controversy and Propaganda on the Air

All network companies and most stations are constantly besieged by individuals and groups who want to promote various causes, and by others who demand that certain causes shall not be presented. Dealing with such demands is one of the most difficult problems in radio broadcasting, especially in the United States, where the companies and stations are supposedly free to do whatever they think best.

Some local stations frankly take sides on controversial topics, just as newspapers do. The networks, however, and many large stations that serve a wide region try *not* to take sides. They settle such problems as best they can by applying two tests: Is a question important enough to deserve time on the air? If it is, how many sides are there to the question? Once that is decided, the company tries to see that every side gets a fair amount of time to present its point of view.

An even greater problem has been that of international propaganda, broadcast by governments to the territories of other nations. At first, radio offered a splendid chance to promote international under-

TEAMWORK IN SPORTS BROADCASTING



Top, a sports announcer broadcasts a swift account of a college football game. Flanking him are students from each school who help identify the players. Bottom, announcers describe a rowing race from a boat train running along the river bank. The train keeps even with the boats along the course.

standing. But during the second World War, government use of radio became an instrument of psychological warfare. Germany prepared for its early military successes by sending threatening broadcasts to countries it planned to invade. Later, Axis countries sent programs directly to Allied troops, calling on them to quit fighting. Then the Allies counterattacked with similar but more successful broadcasts. Each country "monitored" the other's local broadcasts to learn what it could of internal conditions.

Sending American Messages Abroad

After the war the United States began sending "Voice of America" programs to foreign countries. These programs were sponsored by the Office of International Information of the State Department. The programs were designed to create good will and to give other countries an understanding of American ideals and ways of living. The content of the programs was mainly informative, offering news broadcasts, special features on American life, book reviews, and discussions of economics and politics. Some musical entertainment was included.

Although many of the programs were beamed to South America and the Far East, special attention was given to broadcasts to the Soviet Union and countries under its sphere of influence. In many of these places, listening to the "Voice of America" was forbidden. But intelligence reports showed that many people, anxious for news uncensored by Soviet officials, listened to the program, even when imprisonment or worse was threatened. Thus the program became a vital part of the American attempt to "penetrate the Iron Curtain" and inform the people under Soviet domination of American aims and ideals.

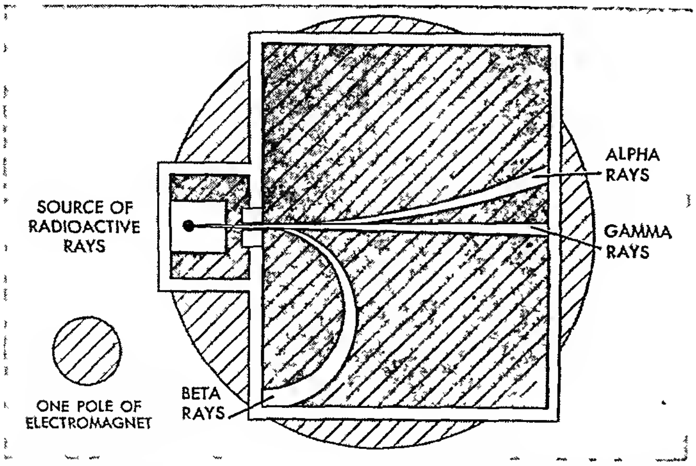
Radio as a Problem for Parents

Listening to the radio has become a leading factor in the leisure activities of the American family. It exercises a profound influence on the tastes, interests, and character development of children. Because it can be done without effort and without thought of expense, it tends to occupy more of their time than either reading or attending motion pictures.

Television too has become an absorbing interest in the American home and exercises an even greater influence on children's minds and personalities. The combination of eye and ear appeals make television completely believable to children.

Child specialists agree that parents should supervise, not only the kind, but also the number of radio programs that are tuned on in their homes. They believe that in many cases children fall into the habit of turning on the radio and listening to it to kill time rather than from a genuine interest in what they hear. They feel that this habit tends to weaken a child's taste for active experiences. They suggest that the child will enjoy the radio more if he confines his listening to a few favorite and varied programs each week.

(The use of radio in the transmission of pictures and facsimiles is covered in the article on Television. For other related subjects, *see also* Electricity; Electrons and Electronics; Radiation.)



A magnetic field (only one pole shown) affects radioactive rays differently. Alpha rays (heavy, positively charged particles) are deflected slightly. Beta rays (light, negatively charged electrons) are deflected strongly the other way. Electromagnetic gamma rays are not deflected.

RADIOACTIVITY—

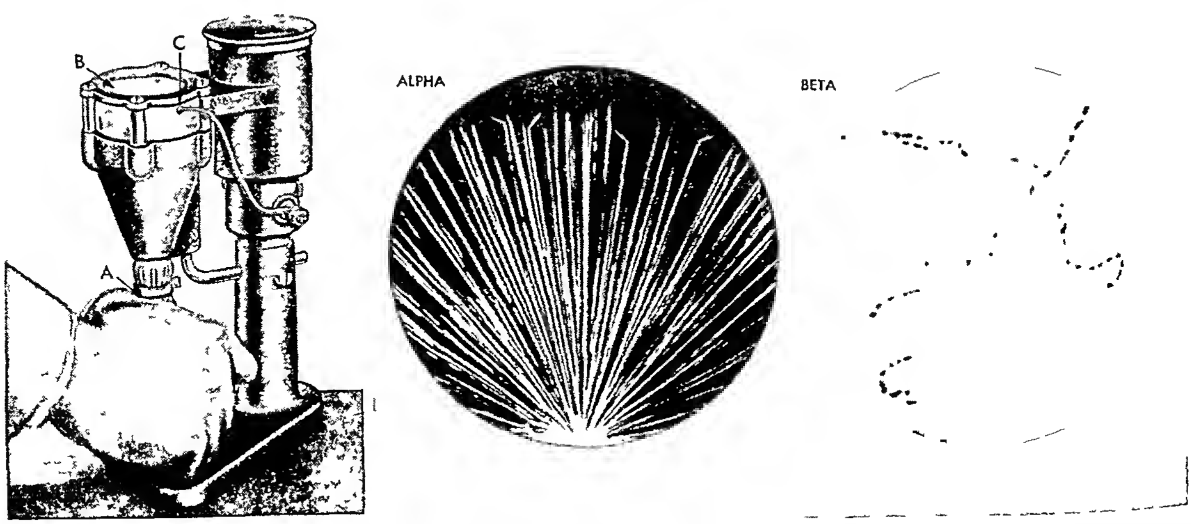
The Action That Transmutes Matter

RADIOACTIVITY. Late in the 19th century, scientists discovered an amazing activity in certain kinds of matter. Through the ages, atoms of these substances have been shooting off particles and emitting radiations (together called "rays") without anyone suspecting that this was happening. When men did discover these strange rays, they found that they could do nothing to change the emissions. Applying heat, electricity, or any other force made no difference whatever. Emission seemed to be an unchangeable property of the substances.

Today many important uses have come from this discovery. A special development used with the element uranium has produced atom bombs and atomic energy. Doctors have found that the rays can penetrate living tissues for short distances and affect the tissue cells. Like X rays, they break down abnormal cells more than normal ones, and so they help in treating cancers and other tumors.

In time, scientists learned how to make all other elements give off these rays. These elements include the important ones which make up our bodies. If such radioactive elements are given in food or otherwise, the rays can be traced through the body. This use of "tracer elements" is extremely helpful in expanding knowledge of our life processes.

Geologists have learned how to use the rays for studying the age of rocks. From this they obtain new checks on the ages of mountain ranges and even the age of the earth itself. Most important of all for science, the study of these rays is a tremendous help in understanding the nature of atoms; and from



A CLOUD CHAMBER FOR STUDYING RADIOACTIVITY

The Central Scientific demonstration type of cloud chamber (left) is partly filled with water. Squeezing the bulb (A) compresses the air inside; releasing it suddenly reduces the pressure. This creates a fog which condenses on any ions present. Tracks of such ions are created by alpha and beta rays from a radioactive substance at C. Under a bright light the tracks can be seen (B). Photographs of such tracks show that heavy alpha particles are rarely deflected by collisions with ions until near the ends of their flight. The light beta particles are deflected strongly and leave thin, wavy trails.

this, in turn, scientists are learning how energy and matter interact to bring about everything that happens in the physical universe.

Learning the Nature of Radioactivity

At first, scientists did not know the nature of these strange emissions, and could only call them "rays." This gave rise to the modern term *radioactivity,* from the Latin word *radiare,* meaning "to give off rays." Modern knowledge of radioactivity can best be traced by seeing how it was discovered, and how with patient experiments and study scientists gradually learned its nature.

The first development came as a result of Wilhelm Roentgen's discovery of X rays in 1895 (*see* X Rays). Henri Becquerel became interested in the fact that the glass of an X-ray tube glows with a greenish light while the invisible radiation is being given off. He wondered, therefore, whether other materials when set to glowing (that is, made fluorescent) might also emit invisible radiation like X rays.

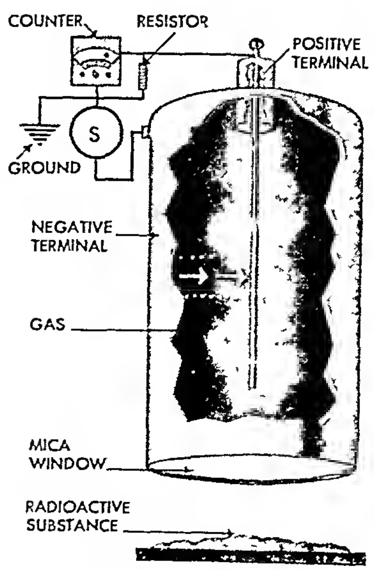
To find out, he wrapped in dark paper samples of several compounds which can be made fluorescent. He then placed each sample beneath a photographic film. Among the substances he tested was a salt of uranium. None of the other compounds affected the film. The uranium salt, however, made a fairly clear imprint. He experimented for several months and found that fluorescence had nothing to do with the result. *All compounds of uranium* affected the film, whether or not they had been made fluorescent. The invisible radiation seemed clearly to be a natural property of uranium.

He found also that when he placed uranium near a charged electroscope, the charge leaked away. It was plain, therefore, that the radiation made the air in the electroscope a conductor of electricity. Soon a young woman, Marie Curie, and her husband, Pierre, made another amazing discovery. She started to test samples of different metals and ores to note the length of time taken by samples to discharge an electroscope.

Strangely enough, pitchblende, a uranium ore, proved four to five times as radioactive as pure uranium, even after the uranium had been removed from the pitchblende. Plainly the ore must contain some other radioactive substance. Madame Curie worked to isolate this substance and eventually found it to be a hitherto unknown chemical element. It was 4 million times as radioactive as uranium, so she gave it the name "radium" (*see* Curie; Radium).

Meanwhile other scientists were discovering the nature of radioactivity. In 1899 Ernest Rutherford found that uranium gave off three different kinds of "rays." One kind was stopped by a sheet of paper or a few centimeters of air. Rutherford named it the *alpha* ray. A second type, the *beta* ray, could go through several millimeters (about one fifth of an inch) of aluminum. A third kind, the *gamma* ray, could pass through as much as 20 centimeters (about eight tenths of an inch) of iron. (The names alpha, beta, and gamma are often written with the Greek letters, α, β, γ, respectively.)

The rays also responded differently to magnetic and electric fields. The picture at the top of the opposite page combines the results of experiments which revealed various responses to magnetic force. The variations could be explained only by differences in electric charges carried by the rays. Experiments made by shooting the rays between electrically charged plates gave a corresponding result. Alpha rays are deflected away slightly from a positive charge and toward a negative charge. Beta rays are deflected



A GEIGER COUNTER AND HOW IT WORKS

These amateur prospectors (left) are using a Geiger counter to test a deposit of minerals for radioactivity. The counter (right) is filled with gas, and a source (S) supplies opposite electric charges to the container and a central tube. The gas, however, blocks flow of current, unless radioactive particles enter through the mica window and ionize some gas molecules. The ions from each "hit" carry a spurt of current across the inside space, and each spurt registers in the counter.

strongly in the opposite direction, and gamma rays not at all. It is well known that like electrical charges repel each other, while unlike charges attract. The deflections were also what was to be expected if the charges are carried by particles having certain masses. Alpha rays must therefore consist of particles carrying a positive charge. Beta rays are particles having negative charge. Gamma rays apparently did not carry a charge at all.

Radioactivity and Atoms

Since the particles and the gamma rays came from within atoms, plainly the particles had somehow been *parts* of atoms. Atoms therefore were not the "smallest units" of matter, as scientists had thought they were. Atoms must consist of still smaller units, such as the particles given off by radioactivity.

By that time, scientists had already discovered the electron, a particle with negative electric charge but only 1/1840 the mass of a hydrogen atom, the lightest in existence. Soon it was proved that beta rays are streams of electrons. Proof was also found that particles in alpha rays are the nuclei of helium atoms, the next lightest after hydrogen.

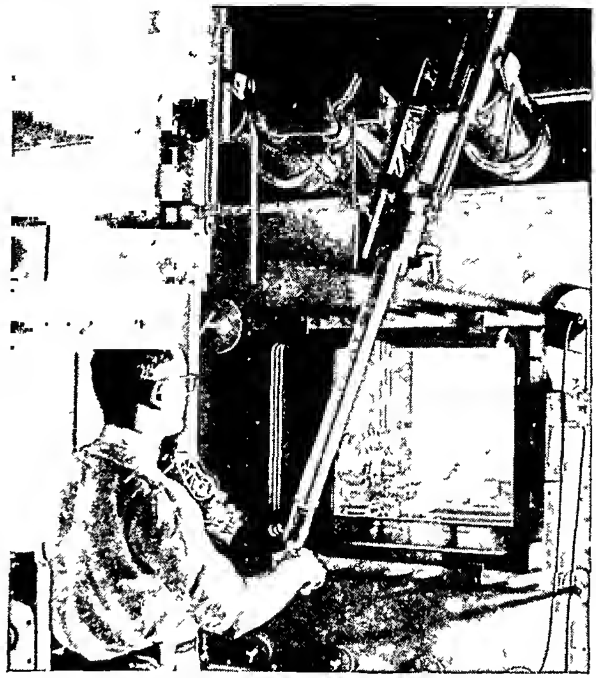
As additional radioactive elements were found, it was learned that the same kinds of alpha, beta, and gamma rays were given off during their transformations, regardless of the kind of element. This suggested that both radioactive and other kinds of atoms must all contain the same kinds of subatomic particles. From this and other discoveries, scientists rapidly built up the theory that every kind of atom is made up of the same subatomic particles (*see* Atoms). Later, gamma rays were proved to be electromagnetic radiation, like radio, light, and X rays, with shorter wave lengths than any X ray then known (*see* Radiation).

Transmutation of Elements

Before the discovery of radioactivity, scientists thought that the atoms of matter were indestructible. Atoms might combine and recombine in endless chemical compounds; but each atom always remained the same through all the changes. The discovery of radioactivity forced a change in this theory. If atoms of uranium and radium lose particles as heavy as nuclei of helium, they could hardly remain the same elements. They must become atoms of something else. Experiments and study revealed the truth of this view. These elements do change—that is, transmute—into other elements.

Radium offers a good example. When one atom of radium disintegrates, two gaseous products result—radon and the helium nucleus (the alpha particle). Each charged alpha particle captures a stray electron and becomes a stable helium atom. The unstable radon atom, in turn, changes into an atom of another element. Other distintegrations follow each other until the series ends with the stable element lead.

The successive changes of one radioactive element into another create a kind of "family" for each series,



SAFE HANDLING OF "HOT" MATERIAL
Thick lead walls keep deadly radiations from this scientist while he uses a periscope and remote controls to work with the radioactive material.

from the parent element to lead. Scientists have found four principal families, or decay series, of radioactive substances—the uranium-radium family; the actinium family; the thorium family; and the neptunium family.

Development of Artificial Radioactivity

In the early 1900's scientists tried to produce radioactivity in ordinary substances but without success. No method then available could apply enough energy to disturb the tightly bound nuclei of atoms. In 1919, however, Ernest Rutherford used the tremendous energy (for their size) of alpha particles to bombard the nuclei of nitrogen. Tests showed that this bombardment changed some of the nitrogen atoms into atoms of oxygen and hydrogen.

In 1934 Frederic Joliot-Curie and his wife, Irene (daughter of Marie Curie), bombarded a piece of aluminum with alpha particles and found that the aluminum gave off radioactive particles for a measurable time after the bombardment stopped. In giving off these particles the aluminum changed into a new substance which had never been found in nature.

The new substance had the chemical and physical characteristics of the element phosphorus, but its atomic weight differed from that of the well-known form. This fact indicated that the substance was a variant form or *isotope* of phosphorus. It was also radioactive. It gave off positrons (beta particles with positive charge) and gamma rays, and as a result it changed into silicon, a stable element. The Joliot-Curies also produced radioactive forms of boron, magnesium, and other elements.

In these early experiments bombarding particles from other radioactive substances were used, since no other particle had enough energy to affect the tightly bound nuclei of atoms. Physicists, however, gradually developed machines which produced and hurled subatomic particles with the required energy (*see* Atoms). With these machines, physicists have produced radioactive forms of every element.

Detecting Radioactivity

Since radioactive particles are too small to be seen by the most powerful microscope, radioactivity must be detected and measured by its effects. One of the first instruments for doing this was the *spinthariscope.* Particles from a radioactive scource strike a plate covered with a sensitive substance and produce flashes of light ("scintillations"). With a microscope these can be seen and counted.

Modern *scintillation counters* detect gamma rays as well as charged particles. A sodium iodide crystal gives a flash of light for each gamma ray, and the flashes are recorded by a photo-multiplier circuit.

Other detectors are the *Geiger counter* and the *cloud chamber.* In each one charged particles, as they pass through, ionize molecules of gas contained in the device. Rutherford and Hans Geiger developed the counter in 1908 for counting alpha particles emitted by radium. The cloud chamber, developed in 1911 by C. T. R. Wilson, provided a means for seeing and photographing the ions (*see* Ions).

Modern Theories about Radioactivity

A FUNDAMENTAL question about radioactivity is why some elements have this property naturally while others do not. The nature of the rays and the heavy atomic weight of most naturally radioactive elements gave physicists two highly important clues. The answer lies in the way in which subatomic particles are held together to make up the nucleus of an atom.

The simplest nucleus in nature is that of hydrogen. It consists of a single proton which carries one positive charge. The positive charge simply holds one negatively charged electron to make the complete atom.

For atomic nuclei having more than one proton, some kind of force is needed to overcome electrostatic repulsion between the positive charges on the protons and thus hold the nucleus together. This so-called *nuclear force* can be thought of as a kind of "stickiness" which acts between subatomic particles when they are close enough together. Nuclear force can act at or within the "sticking distance" but not over any greater range. It differs also from other forces in that it does not fade out gradually with distance.

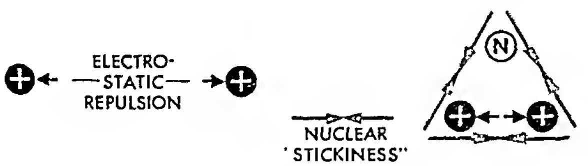
The force cannot be electrical in nature, for it overcomes electrostatic repulsion without otherwise affecting the charges. Another significant aspect of the force is the fact that it acts only when protons are accompanied in a nucleus by another kind of particle, discovered by T. Chadwick in 1932, and called a neutron. A neutron has about the same mass as a proton but no electric charge. Once a nucleus has one or more neutrons, various combinations can be made. For example, one or two neutrons can stick to the one proton of hydrogen, making the "heavy hydrogens" *deuterium* ($_1H^2$) and *tritium* ($_1H^3$). Two protons also can be held with one neutron as an isotopic form of helium ($_2He^3$), as shown in the accompanying pictures.

The symbols show the make-up of the atoms. The small number before and below the chemical symbol $_1H$ for hydrogen shows the number of protons. It is also the *atomic number* which gives hydrogen its place in the order of elements (*see* Periodic Table). The number after and above the H tells the total number of particles, protons plus neutrons. It is called the *mass number,* since this total determines almost entirely the mass of the atom.

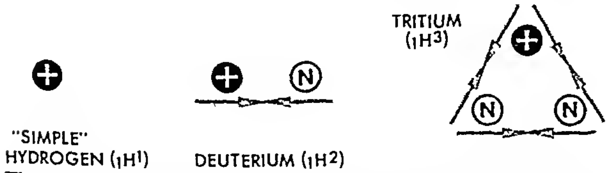
"H^2" therefore means one neutron added to the proton, making the total two. $_1H^3$ is one proton and two neutrons. "Simple" hydrogen is $_1H^1$. Its one proton is also the only particle in the mass number. Helium $_2He^3$ has three particles, like tritium; but two of them are protons, as in "common" helium ($_2He^4$). Therefore, each form is an isotope of helium.

WHY NUCLEI HOLD TOGETHER

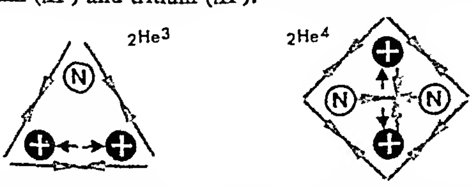
If neutrons are present, nuclear forces can bind subatomic particles into atoms, even though positively charged (+) protons tend to repel each other, as shown below. (The chemical symbols are explained in the article.)



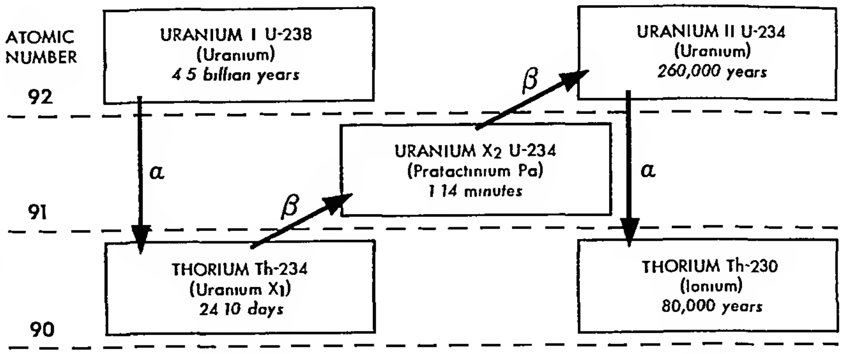
Here (left) positive charges on two protons tend to drive the protons apart. Each proton however, also exerts "stickiness," or nuclear, force (color). With one neutron present, the combined force overcomes the electrostatic repulsion.



Here one neutron and two neutrons respectively stick to one proton of "simple" hydrogen ($_1H^1$, left), to make the "heavy hydrogens" deuterium ($_1H^2$) and tritium ($_1H^3$).

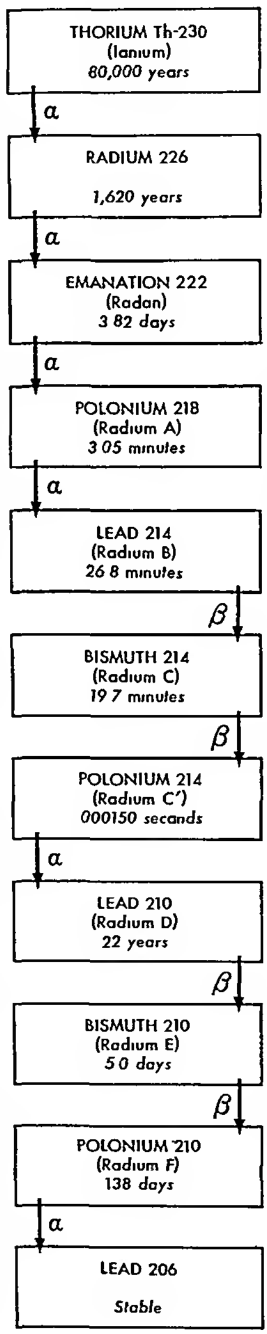


Each heavy hydrogen combination has enough stickiness to hold one more proton. The results are two forms (isotopes) of helium ($_2He^3$) and ($_2He^4$). The form $_2He^4$ is bound firmly enough to be one of the most stable nuclei in nature.



PROGRESSION OF DECAY IN A RADIOACTIVE FAMILY

A family of elements is formed from uranium by emission of alpha (α) and beta (β) particles. The first steps of decay are at the right; others, with thorium 230 repeated, are below. Modern names and mass numbers are followed by names formerly used. In each case, the half life is stated.



The particles in either kind of heavy hydrogen will easily hold another proton, giving two forms of *helium* ($_2He^3$ and $_2He^4$). Helium is the next lightest element after hydrogen. After its electrons are removed, it is the alpha particle of radioactivity. With two electrons, the complete atom is one of the most satisfied and inert of all the elements (*see* Chemistry).

The two forms of helium and the three hydrogens show why variations called *isotopes* can exist for every chemical element. Neutrons provide enough stickiness so that their number can vary somewhat and still hold the required number of protons. The isotopes, however, may or may not be *stable*—that is, able to hold together indefinitely. Deuterium ($_1H^2$), for example, has stickiness enough to be stable. Tritium ($_1H^3$) does not. In time it becomes an isotope ($_2He^3$) of helium by gaining a proton. $_2He^3$ is stable and is found mixed in a slight amount (13 parts in 100,000) with the tightly bound "common" helium, $_2He^4$.

The Neutron-Proton Ratio

In $_2He^4$, the protons and neutrons are exactly equal in number. In heavier elements up to and including calcium ($_{20}Ca^{40}$), this one-to-one ratio holds closely. Only a few stable kinds of atoms depart from it by one or more particles.

Beyond calcium, neutrons are in excess of protons. A diagram on the opposite page shows why the excess is needed to hold larger numbers of protons.

Up to lead ($_{82}Pb^{208}$) and bismuth ($_{83}Bi^{209}$), such excess of neutrons can hold nuclei permanently together in a stable state. No nucleus having more than 83 protons, however, can maintain complete stability even with an ample excess of neutrons. The combinations may hold for a time, but they are held in a state of strain, or *instability*. Disruptive forces tug constantly to break some part of the nucleus away, and every now and then they succeed in doing so. This constitutes a radioactive event. Thus all elements heavier than bismuth are naturally radioactive; and radioactivity continues in them until each kind reaches stability in the form of lead or bismuth.

Families of Radioactive Decay

In only a very few cases do naturally radioactive nuclei relieve all strain and become lead or bismuth by one great change. In most situations, the nuclei have enough holding power to prevent this. Instead, relief proceeds "step by step." All the steps can be grouped in chains or "families," as explained earlier in the article. Why the various steps in each chain occur as they do can only be explained in terms of energy relations.

Binding Energies of Nuclei

Whenever anything happens in nature, energy is involved. Therefore, a fundamental fact about any nucleus is the amount of the *binding energy* which holds it together.

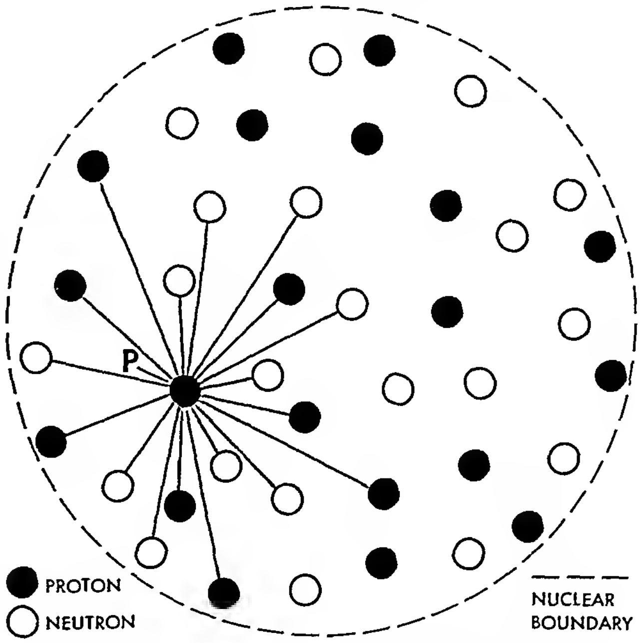
In general, this might be learned by determining how much work it would take to break down the nucleus into its separate particles. Physicists, however, get at the answer "the other way around"—by determining what must have gone into *forming* the nucleus.

This method depends upon a fact which can be described by a comparison in human affairs. Often among men, "a good team" gets along with less effort than is required to maintain the members separately. This same difference exists between nuclear particles existing separately and those organized as a "team" in a nucleus. The team gets along with less total energy than would be associated with the particles existing singly. (The excess is discharged, when the nucleus is formed, by radiating it away.)

A simple clue to *how much less* energy the nucleus needs is given by the Einstein relation between energy and mass: $E=mc^2$. This tells us that any change in the energy (E) associated with mass (m) will be matched by a corresponding change in the mass itself. (In the equation, c represents the speed of light.) Consequently, when total énergy is reduced by formation of a nucleus, it should be matched by a reduction in the total mass. A simple example is afforded by helium (${}_2He^4$).

For such computations, physicists use *mass units*, closely related to actual masses of neutrons and protons. One unit is so tiny, it would take about 5,855 billion billion of them to weigh one ounce. The mass-unit value of a separate proton is 1.0076; and of a neutron, 1.0089. Thus the four particles in a helium nucleus, taken separately, have a mass value of 4.0330 atomic units. Experiments with the mass spectroscope, however, prove that the value of the helium nucleus in mass units is only 4.0028. There has been a *mass loss in binding* of 0.0302. From this figure, the Einstein relation gives the reduction in total energy which occurs as a consequence of forming the nucleus.

Binding energies for other nuclei can be established similarly. In general, the greater the reduction of total energy (that is, the higher the binding energy) the more firmly the nucleus is held together, and the more work would be needed to break it into separate particles. The amount of binding energy for each particle in a nucleus (proton or neutron) ranges from 5.3 million electron volts for lithium (${}_3Li^6$) to about 8.7 mev. (million electron volts) in elements near iron (${}_{26}Fe^{56}$) in the Periodic Table. It decreases slowly for heavier elements to 7.94 mev. for uranium (${}_{29}U^{238}$).



WHY THE PROTON-NEUTRON RATIO CHANGES
Here the proton (P) is held by nuclear force exerted by nearby neighbors. It is electrostatically repelled, however, by every proton in the nucleus. Thus larger nuclei need an excess of neutrons to give each proton uncharged neighbors enough to hold it.

Stability and Instability

Relations among binding energy, electrostatic repulsion, and the motions of the nuclear particles determine whether or not a nucleus will be stable. Older theories could not explain these relations satisfactorily, because they treated the masses, forces, and energies involved in a way that gave only one answer in a nuclear situation. This could not explain radioactivity, because under such a view, nuclei would hold together permanently or not at all. The modern theory of wave mechanics removes this difficulty with a more flexible treatment of interactions (*see* Energy; Matter).

According to wave mechanics, the outcome of any given relation between particles in a nucleus can vary millions of times a second through certain ranges. Results under older theories often turn out to be averages of the variations. (More correctly the results under the older theories are the most likely, or *most probable*, which occur as a given relation runs through its possible variations.)

As a rule, what happens depends upon how these averages match up. In many of the atoms in nature having 83 protons or less, the margin of holding power is sufficient to keep the atom stable, because no variations can be extreme enough to produce a breakout for some one particle. In atoms having 84 protons or more, however, electrostatic repulsion is great enough to make the margin very thin, and occasional breakouts can occur. How often this happens depends upon how often extreme variations match up in the necessary way. This explains the different half lives of the radioactive elements.

Radioactive Half Lives

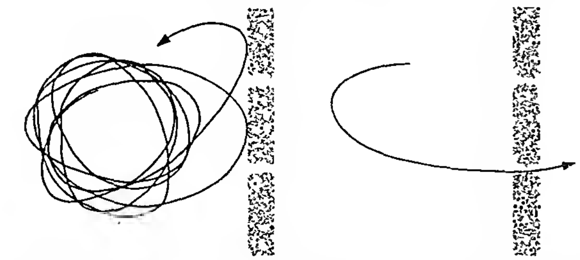
One of the early discoveries about radioactivity is the fact that the different elements decay at different rates. These rates are measured as "half lives"—that is, the time taken for one half of any given quantity of a radioactive element to decay into something else. The longest common half life is that of uranium 238. It is 4.5 billion years. The half life of radium 226 is 1,620 years. Some isotopes have half lives of minutes, seconds, or even less than millionths of a second.

An important feature of half lives is that the second half does not decay completely in the second half life. Only one *one half* of the remainder does; and of what is left, only one half decays in the *next* half life.

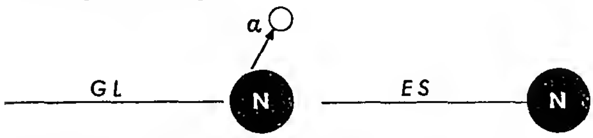
All this follows from the fact that the rate of decay is fixed by how often the favorable variations which permit escape occur. Each atom "takes its chance" as to when this will happen to it. If a half life is 1,000 years, for example, and an atom has survived 1,000 years without an emission, this does not mean that it is next in turn. This still depends upon whether or not the "escape combination" of circumstances will occur for it in the next 1,000 years. Im-

KINDS OF RADIOACTIVE DECAY

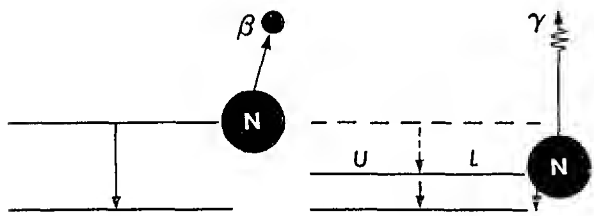
Shown below are the ways nuclei give off the alpha, beta, and gamma rays which appear in natural radioactivity. They show also how the emission of one type of ray leads to another, as explained further in the article.



Here (left) variations in the state of an alpha particle are represented as swings of different shapes and size, while the force that holds the particle to the nucleus is a wall with holes. Swings that reach the barrier usually hit the wall; but if one of them hits a hole the particle escapes.



Here (left) a radioactive nucleus is at its *ground level* (GL) of energy. When it emits an alpha particle, the remaining nucleus will be in an excited state (ES, right). The nucleus then must discharge some excess energy.



Perhaps the nucleus can reach temporary stability by emitting a beta ray (left). This might, however, just bring the nucleus to an unstable level (UL). By emitting an electromagnetic gamma ray photon (γ), it may then achieve temporary stability.

mense numbers of atoms must be involved before the "law of averages" can establish a *rate* of disintegration for the atoms involved. Thus in any mass of radioactive atoms, some will last almost indefinitely, even though the number diminishes constantly. Hence traces of any element having a fairly long half life can be found today, in spite of the immense lapse of time since the universe began.

The Process of Alpha-Ray Emission

The emission of an alpha particle is a drastic radioactive change. It carries away two neutrons and two protons with their charges as well as the kinetic energy carried by the escaping particle. It may be that the emission consists of a helium nucleus instead of one or more protons, because protons and neutrons tend to group themselves firmly in this way, even in a nucleus. This, however, is by no means certain.

The favorable combination of variations which permits the escape of an alpha particle can be explained simply by picturing the particle as whirling about within the nucleus. The restraining nuclear force may be considered as a wall, or barrier, surrounding the nucleus at a certain distance.

Under older theories, this wall would be solid and unchangeable, and the alpha particle would have enough energy to get through quickly or not at all. Modern theory considers the restraining force subject to variation; and the variation can be thought of as opening "holes" or "tunnels" in the wall.

Usually, in its whirlings about, the alpha particle strikes a "solid part" of the wall and is turned back. (More accurately, conditions are such that the restraining force is effective.) Every so often, however, the particle may "strike a hole," get through, and escape. The difference in half lives depends upon how often this occurs.

Emission of Beta Particles

Before an alpha emission, the nucleus had a ratio of neutrons and protons which would usually hold it together against the whirlings of the alpha particles (or the particles which make them up). As long as the nucleus remains undisturbed, its energy state under these conditions is often called its *ground level.*

An alpha emission carries away an equal number of neutrons and protons and reduces the restraining ratio of neutrons to protons slightly. This affects the restraining force unfavorably, and something must occur to change the nucleus to an arrangement that will be more nearly stable.

Some situations provide opportunity for doing this by emitting another alpha particle. Others favor the emission of an electron, with its negative charge, as a beta particle. The source of the electron is an outstanding feature of the modern theory. Complicated but well-established reasons tell us that it could not have existed in the nucleus before the emission. It must therefore be created at the instant of emission, by drawing it from a neutron. As a result, the neutron changes to a proton. This *raises* the atomic number by one and makes the neutron-proton ratio more favorable. The diagram of the uranium-radium series on an earlier page shows the zigzag progress of atomic numbers from 92 to 90, back to 92, and down to 90 again.

As a radioactive nucleus decays toward lead, it emits alpha particles until the neutron-proton ratio becomes too great. Then the nucleus steps up in atomic number with one or more beta emissions, before it emits an alpha particle again. Uranium I 238 drops by alpha emission to thorium 234 (formerly called uranium X_1), then comes back by two beta emissions to uranium II 234 before it transmutes to thorium 230 (ionium). Other zigzagging occurs until stability is reached in the element lead.

The Neutrino and Gamma Rays

Emission of a beta particle produces an energy change in the nucleus. The observed energy changes, however, do not "add up" to satisfy the principle that energy must be conserved. (Physicists believe that the "law of conservation of energy" must hold true in

all situations). To preserve this principle, physicists assume that the necessary energy adjustment is achieved by emission, along with the beta particle, of another particle called a *neutrino.* This is a tiny particle which has no electric charge. It probably has "zero rest mass"—that is, no mass until it flies out as part of a beta emission. Then it carries the amount of mass needed to "balance out the energy account." (It is customary in physics to conserve energy, momentum, and "spin," but not mass as such. Mass is considered because it is involved with velocity in the momentum of a flying particle.)

The tiny mass and lack of charge make the neutrino an extremely difficult subject for observation and experiment. Much indirect evidence has been found for its existence; but in the main, it is still a theoretical particle used in physics to make the known facts "add up."

Excess energy in a nucleus can also be relieved by emission of gamma rays. These are electromagnetic radiations which carry less energy than would be discharged by an alpha or beta emission. The mass equivalent of a gamma ray, under the Einstein relation, is too small to be detected by any means now available to physicists. In natural radioactivity, gamma rays are emitted in situations which do not offer available energy losses sufficient for a particle emission. Gamma rays can carry away the smaller amount needed to achieve some more stable state. As such, they are omitted from the decay steps shown on an earlier page, since they do not affect the number of particles in a nucleus and do not change either the atomic or the mass number.

Methods of Producing Artificial Radioactivity

These natural radioactive processes suggest that radioactivity can be induced in naturally stable elements if means can be found to hurl particles at the nuclei with sufficient energy to bring about a transmutation. In fact, nature provided a means for doing this with light elements by using alpha particles from naturally radioactive substances, as told earlier in the article. The development of atom-smashing machines finally made it possible for physicists to transmute every element.

For bombarding particles physicists most often use (in addition to alpha particles) neutrons, protons, and deuterons (nuclei of the "heavy hydrogen" deuterium, $_1H^2$). Carbon and other heavy particles are also used. This choice of particles and the fact that machines can develop energies well in excess of any available energy from natural radioactivity enable physicists to produce transmutations and other effects never seen in natural radioactivity.

The Electron's Opposite, the Positron

Artificial radioactivity (like cosmic rays) can produce positrons—particles identical with electrons, except that they have positive electric charge. A positron is detected readily in a cloud chamber placed in a strong magnetic field. It curves by the same amount as an electron of equal energy, but in the opposite direction. Apparently, just as a beta-ray electron is drawn from a neutron, a positron is drawn from a proton, which becomes a neutron. (Positrons are sometimes called positive beta rays.)

The choice between the production of a positron or an electron for a beta-ray emission is linked to the neutron-proton ratio. If neutrons are too much in excess, one may be changed to a proton by beta-ray emission of an electron. If neutrons are needed, the beta ray may be a positron, with conversion of a proton to a neutron. In either case, a neutrino is emitted.

Positrons also reveal what seems to be a direct conversion of matter into energy and back again. When an extremely high-energy gamma ray passes through a strong electric field, such as exists near an atomic nucleus, it may be converted into a "pair" —that is, a positron and an electron. Oppositely, a positron may unite with a free, or loosely held, electron to produce two gamma ray photons which fly away in opposite directions.

Radioactive Tracer Elements

The ability to transmute any element has enabled physicists to produce radioactive forms (isotopes) of the common elements which enter into food and the tissues of the body. The radioactive isotopes are as good chemically as stable ones, and the body accepts them readily. Once in the body, the progress of the elements can be traced with Geiger counters. Thus these "tagged" elements enable scientists to trace vital processes with extreme accuracy. Elements are selected according to whether or not they have special affinity for blood, bones, brain, or other tissues. Radioactive elements can also be selected to enter diseased tissues as an aid in suppressing unwanted cells. Radioactive iodine is used in this way for treating the thyroid gland.

Radioactive elements can also be used to help trace the course of many industrial and chemical processes. Supplies for all such uses are provided by the Atomic Energy Commission.

Measuring Units in Radioactivity

An important measuring unit for radioactivity is called the *curie*. It is used to tell how much radiation is being given out. One curie amounts to about 3.7×10^{10} (37 billion) emissions a second.

An important dimension is the so-called radius (*rho*) of a nucleus. Its value is (very nearly) 1.2×10^{-13} centimeters, multiplied by the cube root of the element's atomic number. (1.2×10^{-13} centimeters would have to be multiplied by about 20,000 billion to equal one inch.) From this formula and the fact that a nucleus is roughly spherical, it follows that the density of particles is about the same in all nuclei. This density is incredibly high. If a cubic centimeter of matter were as dense as this, it would weigh about one quarter billion tons. A cubic inch correspondingly would weigh about 4 billion tons.

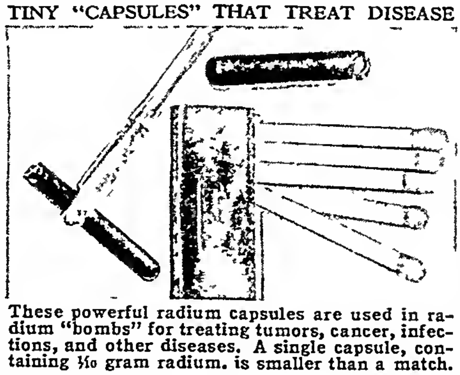
RADIUM. Among many amazing discoveries made about the dawn of the 20th century, one of the most astonishing was that of radium. Not only did it aid in revolutionizing scientific views about the nature of matter; it brought fame to a hitherto unknown young woman scientist, Marie Curie (*see* Curie).

MADAME MARIE CURIE
Discoverer of Radium

Her interest was aroused by Antoine Henri Becquerel's discovery, in 1896, of radioactivity exhibited by compounds of uranium (*see* Radioactivity). At once she set to work to compare the activities of different compounds of uranium and to test other chemical elements for possible radioactivity. In these experiments, she measured the activities with a sensitive electrometer.

One of the ores of uranium, pitchblende, proved to have three or four times the activity of uranium oxide. Madame Curie reasoned that some new, previously unknown element must be present in the mineral to produce this activity. With the help of her husband, the French physicist Pierre Curie, she searched for this hypothetical substance. In July 1898, the Curies announced the existence of a chemical element with about 400 times the activity of uranium. This element was always precipitated with compounds of bismuth, an indication that its chemical properties were similar to those of bismuth. To this new element, Madame Curie gave the name *polonium*, in honor of her native country, Poland.

TINY "CAPSULES" THAT TREAT DISEASE



These powerful radium capsules are used in radium "bombs" for treating tumors, cancer, infections, and other diseases. A single capsule, containing 1/10 gram radium, is smaller than a match.

The Discovery of Radium

In their work with pitchblende the Curies had found that another radioactive substance was separated from the ore along with barium compounds. By repeated fractional crystallization of barium chloride, they formed a crystalline substance with some 900 times the activity of uranium. Since they and their chemist collaborator, G. Bémont, knew that barium was not radioactive, they concluded that still another element gave the radioactivity. On this basis they announced in December 1898 the existence of a radioactive chemical element which they called *radium*.

In 1902 Madame Curie succeeded in isolating one-tenth of one gram of radium chloride which was entirely free from barium. Pure radium alone was not isolated until 1910, by Madame Curie and André Debierne. Its activity proved to be more than 1,000,000 times as great as either uranium or thorium.

Properties of Radium

Radium is a silvery-white metallic element. Chemists assign it the atomic number 88, meaning that there are 88 protons in the nucleus of the atom (*see* Atoms). Its atomic weight is 226.05; its melting point and boiling point are 1,760°F., and 2,084°F., respectively.

In a pure form, radium combines readily with water, air, and the acids. It has a valence of two (*see* Chemistry).

Uses of Radium

Radium is rarely used in the pure state. The most common form is a salt such as radium chloride or radium bromide. About 85 per cent of the world's radium is used to treat malignant growths. Minute quantities may be injected, or the radioactive gaseous element, radon, which results from the disintegration of radium, may be used in a tiny glass container called a *seed*. Some institutions use a relatively large amount of radium in a so-called *bomb*, a lead container on a mount resembling those used for X-ray tubes.

Radium is used in radiography for showing up texture and flaws in metals. The luminous paint industry also makes use of radium. One-thousandth of one gram of radium combined with phosphorescent zinc sulphide can illuminate the needles on thousands of automobile and airplane dials.

Dangers of Using Radium

Pierre Curie deliberately "burned" himself with radium in order to report its action on the tissues. At first the dangers were not realized and many workers died from the effect of the radiations. Today, workers who handle radium are protected by thick cases of lead or concrete. They are tested frequently for anemia which is one of the first signs that the deadly rays are at work. Radiation detectors such as Geiger counters are kept about to detect radioactivity outside the containers.

How Radium Is Prepared from Its Ores

More than 100 ores contain traces of radium. The most important radium ore is *pitchblende*, a black, heavy, noncrystalline uranium mineral. Others are *uraninite*, a gray-black, crystalline uranium ore, and

carnotite, a bright-yellow, soft mineral. The best grade of pitchblende is mined in the Great Bear Lake region of Canada. Large amounts are also found in the Belgian Congo. About ten tons of Canadian pitchblende yield one gram of radium, while 20 tons of the Congo ore will produce the same amount.

Radium is extracted from ores in much the same way Madame Curie used. First the ore is crushed, then boiled with acids. Next it is treated with various chemicals. The waste products boil off, or precipitate, until only a crystalline salt, barium chloride, and a trace of radium chloride are left. Finally, the chemist separates the radium in the salt by repeated processes called fractional crystallizations.

Since the discovery of radium, only about three pounds have been produced throughout the world. Pure radium costs about $25,000 a gram, or $25 a milligram (a thousandth of a gram).

Rail and Coot. Thin compressed bodies, short rounded wings, stumpy tails, and strong legs characterize the family *Rallidae*, to which the rails, coots, and gallinules belong. About 180 species of this family are distributed over the world, 15 inhabiting North America. Most rails have long, slightly curved bills, but the beaks of the coots and gallinules are short and stout. All live and nest among the rushes of the swamp, feeding on insects, small forms of water life, and seeds.

These birds are like chickens. When frightened they run rather than fly, and their chatter in the marshland sounds like the cackling and clucking of domestic hens; so it is not strange that people call them mud-hens.

The rails are a secretive lot, keeping under cover in the daytime and coming out towards evening to walk along the edges of the pond. During the hunting season many are killed as game. When flushed from the reeds, they make easy targets for the sportsmen as they wing their awkward way with dangling legs. The birds migrate southward in the fall and their short wings carry them surprisingly far. Many make non-stop flights across the Gulf of Mexico to their winter home in South America; others cross the sea to distant Bermuda.

Most rails prefer fresh-water sloughs, but the salt marshes of the Atlantic coast are the haunts of the clapper rail. The smallest American rail is the black rail, 6 inches long; the largest is the majestic king rail, measuring more than 17 inches. The sora is the most common and widely distributed American rail.

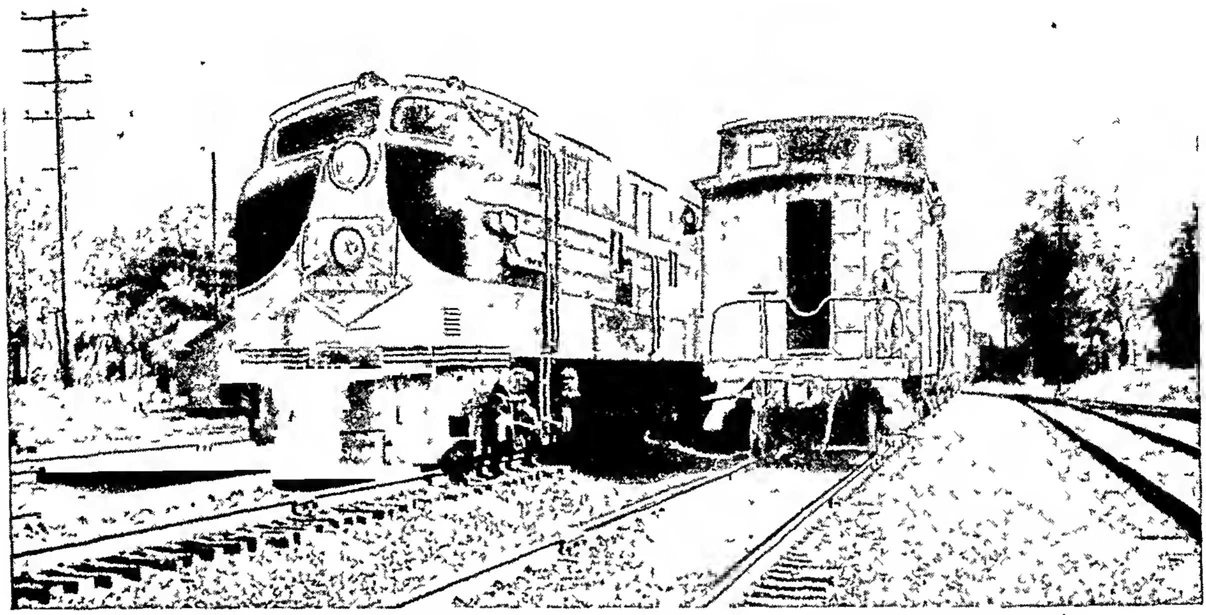
Coots push themselves along through the water with feet well adapted for swimming, with each toe fringed with a scalloped membrane. The American coot is about 15 inches long, with slate-colored plumage that merges into black on the head and neck. Its bill is ivory-white and its frontal plate light brown. Its nest is a raft made in the water from dead stems woven together like a wicker basket and anchored to the reeds. The coot lays from 7 to 16 eggs.

The gallinules swim about on ponds and lakes, but also spend much time in bogs. They are found mostly in the southern United States, but the Florida gallinule breeds as far north as southern Canada. The plumage is slate-colored, tinged with brown on the back, and the bare plate on the forehead is red. The purple gallinule is named for its purple plumage; it wears a blue shield over its carmine-colored bill.

The scientific name of the sora rail is *Porzana carolina;* king rail, *Rallus elegans elegans;* black rail, *Creciscus jamaicensis stoddardi;* American coot, *Fulica americana americana;* Florida gallinule, *Gallinula chloropus cachinnans;* purple gallinule, *Ionornis martinica;* clapper rail, *Rallus longirostris.*

THEY LOVE DAMP HOMES

In the upper left corner is a coot, ready to pounce on some water insect. Next to it is a sora rail alighting on its nest. In the damp marsh below, you will recognize the coot by its black head. Next to the coot is a clapper rail; below, a king rail. The smaller bird at the left is a Virginia rail and at the right another sora.



Swift and Dependable Trains Make Railroads the World's Greatest Transportation Service

RUNNING *the* TRAINS *on* TIME

RAILROADS. Almost every city and town in the United States is on or near a railroad. The railroad serves the people of the community in many ways. It carries travelers to and from other communities near or far. It brings in many of the things that people eat, wear, and use. It carries away products manufactured in the community or raised on nearby farms. It brings in and picks up mail and express packages.

Railroads are specially equipped to perform these services on a broad scale. For carrying large numbers of people and great quantities of goods, the railroad uses the least fuel, mechanical power, and human labor of all land transportation methods. Many railroads, trucking companies, and bus lines work together, each doing the part of the transportation job that it is best equipped to do. (*See also* Buses; Trucks.)

The network of railroads across the United States binds the nation together. Minnesota people eat Florida oranges; Texas people drive Detroit-made automobiles. These and countless other products are delivered by railroad. Every year millions of people take business or pleasure trips by railroad. Wherever new railroads have been built, natural resources are developed, businesses and industries grow, and the community prospers. (*See also* Transportation.)

A railroad is made up of many things—tracks, cars, locomotives, and all the buildings and equipment needed to run it and maintain it. It also includes the people who work on it. All these form a giant transport machine that works efficiently and cheaply.

Railroads Began with Tracks

From primitive times until the early 1800's, the only way to move loads overland was by using the physical strength of men and animals. Freight had to be carried in single vehicles, such as wagons, each pulled by its own animal power and controlled by its own driver. The amount of freight that could be carried in this way was small, and the passage was slow.

The coming of the railroad introduced two new elements in land transportation. One was the locomotive, which concentrated into one unit the pulling power of many horses. The other made use of this power by linking many separate cars into a new kind of vehicle, the train.

Underlying these two new elements was a third—the track, or road of rails. Track must be strong enough to support the weight of cars and locomotives. It must also be smooth enough to offer minimum friction to rolling wheels. Other strong, smooth surfaces, such as highways, could do these two jobs. The raised, parallel rails of track perform a third, and unique, task. Working with flanges on the wheels, the rails guide all the cars of a single train as they are pulled along behind the locomotive.

There were tracks before there were trains and locomotives. During the late 1500's short wooden tracks were built in England to connect mines or quarries with nearby streams. Here the stone or coal would be transferred to barges. On such tracks horses drew far heavier loads than they could pull on ordinary roads. These short tramways, later built of iron, became very common in England.

First Use of Locomotives

In 1804 Richard Trevithick, a British mining engineer, planned and built a steam locomotive. His engine actually pulled a short train of cars up-

hill on a coal-mine railway in Wales. In the years after Trevithick's locomotive, several others were built for use on various British coal-mine railways.

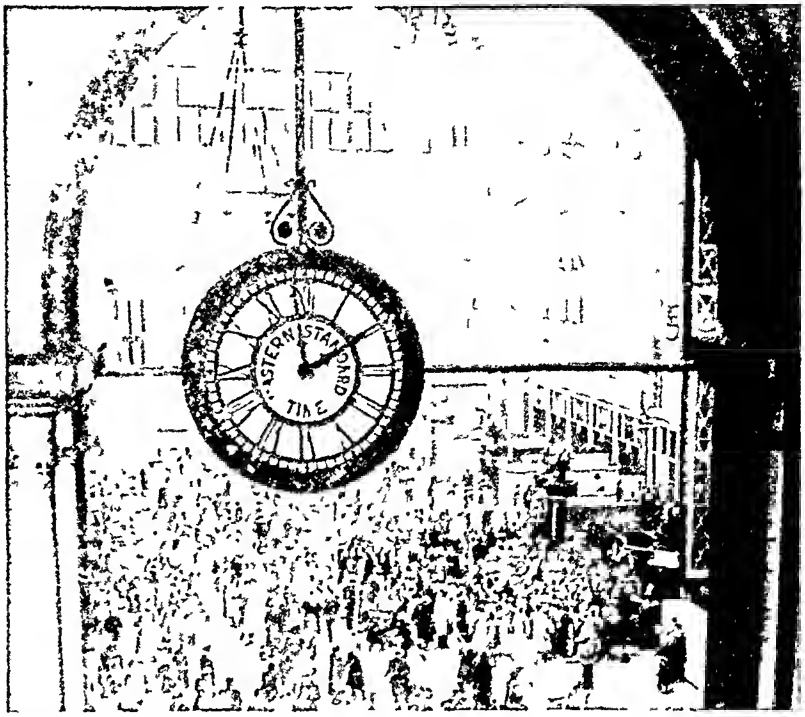
The world's first common carrier railroad (that is, one for public use) to use steam power was the Stockton and Darlington in England. It was designed and built by George Stephenson and opened for public service in 1825. In 1829, in the famous locomotive trials held at Rainhill, England, on the Liverpool and Manchester Railway, the *Rocket*, built by Stephenson and his son Robert, showed its superiority as a steam locomotive. Though it was not the first such locomotive, it is looked upon as the beginning of effective steam power. (*See also* Locomotive.)

First Railroads in America

American colonists also built short tramways for hauling stone or coal. In 1804 Oliver Evans (who had built an amphibious steam-powered scow with wheels) declared that he could "make a steam carriage that will run 15 miles an hour on good, level railways." As early as 1812 Col. John Stevens, of Hoboken, N. J., began to speak for a new kind of "rail-way." He wanted one that would furnish long-range transportation, linking distant sections of the nation. In 1815 Stevens obtained the first charter to build a railroad across New Jersey, but he was unable to raise the money needed to build it.

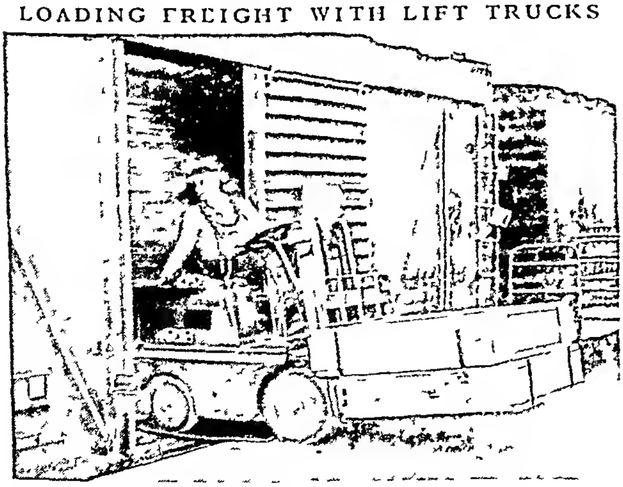
The first American common carrier railroad to be chartered (1827) and built was the Baltimore and Ohio. Construction started on this road July 4, 1828. The first steam locomotive to run in America, the English-built *Stourbridge Lion*, made a trial trip over the tracks of the Delaware and Hudson Canal Company in Pennsylvania in 1829. The engine was too heavy for the track and the trip was not repeated. In the summer of 1830 service began on the Baltimore and Ohio, with horses as the motive power.

ALMOST A CITY IN ITSELF



The Pennsylvania Station in New York City is one of the world's largest terminals. It offers a host of goods and services to the thousands who pass through it daily.

LOADING FREIGHT WITH LIFT TRUCKS



Less-than-carload (L.C.L.) freight is handled quickly and easily by fork lifts such as this one which can carry two-ton loads.

Finally in December 1830, an American-built locomotive, the *Best Friend of Charleston*, hauled a train of cars on the tracks of the South Carolina Railroad. The new operation combined the four essentials of track, trains, mechanical power, and common carrier service. The railroad had come to America.

Railroads Cross the Continent

Railroads were born in England, a country of dense population, short distances, and large financial resources. There problems were very different from those in America, where great distances were to be spanned in regions of thin population with limited capital. Americans had to learn to build railroads for their own country by actual experience; they could not copy English methods.

The first American railroads started from the Atlantic ports of Boston, New York City, Philadelphia, Wilmington, Charleston, and Savannah. Within 20 years four rail lines had crossed the Alleghenies to reach their goal on the "Western Waters" of the Great Lakes or on the tributaries of the Mississippi. Meanwhile other lines had started west of the mountains, and by the mid-1850's Chicago, St. Louis, and Memphis were connected with the East. Still other lines were stretching westward beyond the Mississippi. An international route connected New England and Montreal and another one crossed southern Ontario between Niagara, N. Y., and the Detroit River.

During the 1850's north-and-south routes were developed both east and west of the Alleghenies. It was not until after the Civil War, however, that a permanent railroad bridge (as distinguished from a

THE FIRST RAILROAD TO CROSS THE CONTINENT

Officials and workers gather at Promontory, Utah, May 10, 1869, to celebrate the completion of the first chain of railroads to provide service between the Atlantic and the Pacific.

temporary wartime structure) was built across either the Ohio River or the Potomac River.

After the Civil War railroad building was speeded up. The two Pacific railroads—one building westward from the Mississippi River the other eastward from the Sacramento—were started during the war to promote national unity. They were joined at Promontory, Utah, on May 10, 1869, to complete the first rail connection across the continent. Other lines across the Rockies and on to the Pacific followed. Today there are seven such lines in the United States and three in Canada. The United States has no route across the continent under the operation of a single company, but each of the Canadian routes has its own truly transcontinental line.

United States Railroads Today

In 1870, when the railroad movement in the United States was 40 years old, there were 54,000 miles of line. (A mile of line is a measure of length of single main track, not including second and other multiple main tracks, sidings, passing tracks, or yards.) Between 1870 and 1880 another 40,000 miles were added, and in the decade after that, 69,000 miles. This decade (1880–90) marked the most rapid expansion of American railroad lines. Growth continued with another 30,000 miles in the 1890's and 47,000 miles in the 1900's. After 1910 the railroad network was largely complete, and there was little further extension. In 1920 there was a total of 253,000 miles of line. By 1950 this had declined to a total of less than 225,000 miles.

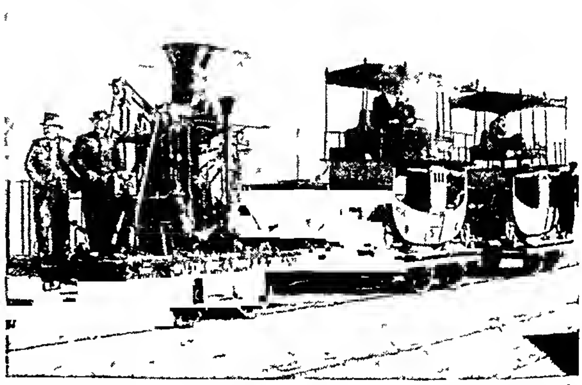
This decrease did not mean a decline in demand for railway service. On the contrary, railroad freight traffic doubled between 1920 and 1950, and the decline in total passenger traffic was small. The disappearance of certain trackage was due to a shift in the nature of railway traffic. Some of the abandoned lines had been built to serve mines, forests, and other exhaustible natural resources and had served their purpose. Others served places where traffic was too light to warrant the continued operation of a railroad after the development of motor vehicle transportation. A few of the abandoned lines had been built to serve a future need which never materialized. In the same period during which nearly 30,000 miles of line were abandoned, the railroads spent an average of more than 500 million dollars annually to add to the capacity and to increase the efficiency of the remaining mileage.

Between 1850 and 1871 the United States government made grants-in-aid of vacant lands to railroads as a means of encouraging and assisting the extension of lines in the West and South, in many instances ahead of settlement. These land grants were not outright gifts because in return the railroads were required to haul government traffic at reduced rates. In 1946 Congress terminated the arrangement. It was estimated that through deductions from regular rates, the railroads collectively had paid the government about nine times the original value of the lands received by grants.

Building a Railroad

Before a railroad is built there are usually several alternate routes to be considered. Rough maps and profiles showing the features of each one are prepared. Experts then choose the best route; the choice they make has much to do with the success or failure of the new railroad line.

THE ORIGINAL 'ATLANTIC' LOCOMOTIVE



The sturdy old 'Atlantic' can still pull two Imlay coaches. It first went into operation on the Baltimore and Ohio in 1832.

One route may be fairly level, requiring only a few *cuts* through hills and *fills* through valleys. Such a route, however, may require a tremendous tunnel to get under an intervening mountain or several expensive bridges. This would make it more costly in the end than one with moderate cuts and fills all the way. Another route, though less expensive to build, may run through unsettled country. Hence it may be wiser to build the more expensive line for the sake of the greater local business it can get.

The selected route is then surveyed carefully and building commences. Sometimes work parties begin at each end and build toward the middle. The completed track carries trains with supplies for the workmen. Today parties can be stationed at various points and be supplied from other railroads already built nearby. This method gets the road finished and earning money much more quickly.

The first step is the preparation of the roadbed. Following the stakes and plans set up by the surveyors, the working parties clear away trees, make cuts and fills, and otherwise prepare the way. Other workers set up bridges and dig tunnels.

As fast as the roadbed is ready, the track is laid, either by hand or by machines which feed the ties out on a belt and put the rails in position. Working on level ground, tracklayers can complete several miles in a day. Then the track must be ballasted, preferably with gravel, cinders, or stone, and finally "seasoned," or shaken down.

In America the usual practice has been to build a single-track line with as few tunnels, bridges, and expensive cuts and fills as possible. When the railroad starts earning money, short cuts, called *air lines*, are made to eliminate sections of winding track which were built to avoid tunneling or grading. Then the track is doubled, first at portions where most trains pass and finally over the entire route, and thus the railroad grows into a first-class line. This method was largely responsible for the great development of railroads in America. It enabled companies to build roads in comparative wildernesses and make them pay. The railroad built up the community, and business from the community in turn enabled the railroad to improve itself.

From Wooden to Steel Track

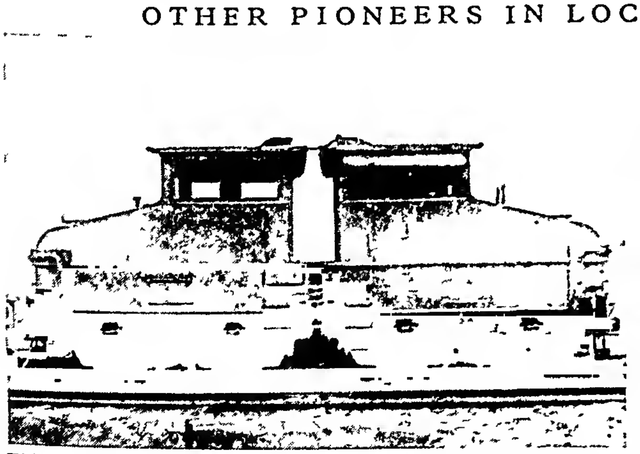
The earliest track was built of wooden stringers faced with iron straps or of short iron rails fastened to stone blocks. Neither proved satisfactory. By 1831 a new type of construction had been worked out by Robert L. Stevens of the Camden and Amboy, in New Jersey. Stevens devised a form of rail known as the "T" rail (although in cross section it looks more like an "I"). The base was flat and could be fastened by hook-headed spikes directly to wooden crossties. This arrangement not only supported the rails but held them in line and at the right distance apart.

Despite many improvements in design and construction, the basic track ideas of the 1830's have continued in use. Rail has changed from iron to steel and has grown in length, height, and weight and in strength, safety, and wearing qualities. The life of crossties has been more than trebled by impregnating them under pressure with preservative chemicals. Protective tie plates between rail and tie are in nearly universal use in main-line tracks, and resilient pads between plates and ties are widely used. Joints and fastenings have been improved in design and strength. Along many miles of track, especially through tunnels and other places where maintenance is particularly difficult, joints have been largely eliminated by welding rails end-to-end into long unbroken ribbons of steel.

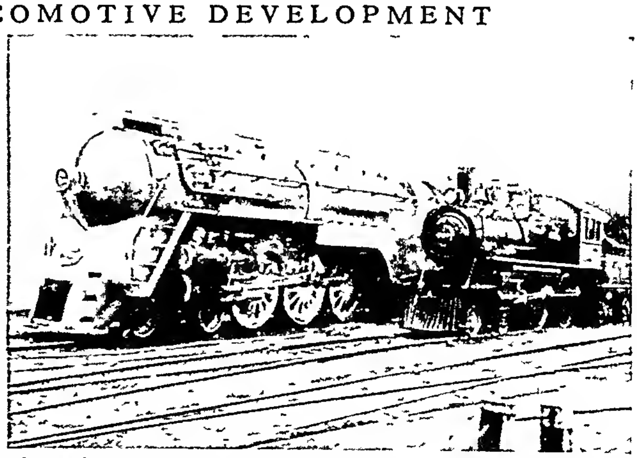
In the early days, each railroad built its track of whatever width it pleased and then built its engines and cars to fit that width, or *gauge*. The tracks at the Killingworth Colliery, for which George Stephenson built his first locomotive, happened to be 4 feet 8 inches between rails, so Stephenson built his locomotive for this gauge. When he designed the Stockton and Darlington he made the locomotive the same width but added another half inch to the width of track. This odd measurement of 4 feet 8½ inches in time came to be known as *standard gauge*.

Other tracks in England ranged between two and seven feet. In the United States the early railroad

OTHER PIONEERS IN LOCOMOTIVE DEVELOPMENT



This battery-powered electric locomotive, one of the first of its kind, began operation in 1895 in a tunnel under Baltimore.



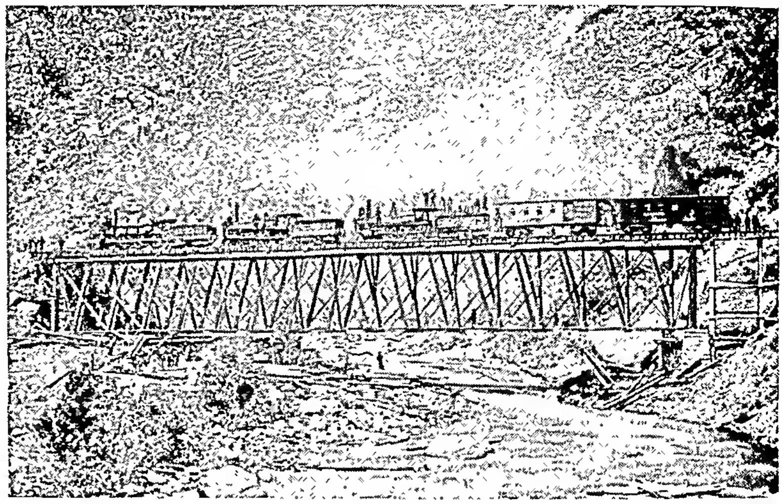
Alongside a modern streamlined engine stands old No. 999. It held a world speed record (1893–1905) of 112.5 miles an hour.

tracks ranged from three to six feet in width. As long as lines did not connect and there was no demand for through service, this variance made no particular difference.

Standardization of Gauges

Soon freight began to move longer distances and over the lines of more than one railroad. The differences in gauge forced the costly nuisance of unloading and reloading. Most of the lines in the area between New York City and Chicago were of nearly the same gauge, between 4 feet 8 inches and 4 feet 10 inches. Thus in the 1860's arrangements were made to run through cars especially equipped with broad-tread wheels which could be used on any of these widths. About the same time the movement toward standardization of the 4 feet 8½ inch (Stephenson) gauge received great encouragement when Congress adopted it for the new Pacific railroad.

EARLY RAILROADS CONQUERED ROUGH TERRAIN



Early railroad builders tried to avoid costly tunnels and bridges. This is Devil's Gate Bridge across Weber Canyon (Utah) in 1870.

By the mid-1880's there was virtually a double standard of gauge in the United States. In the North and West the Stephenson gauge prevailed; most of the South used a gauge of 5 feet. Starting in 1886, the Southern lines narrowed their tracks to the now standard gauge of 4 feet 8½ inches. Soon this uniformity insured an uninterrupted flow of commerce over the entire nation.

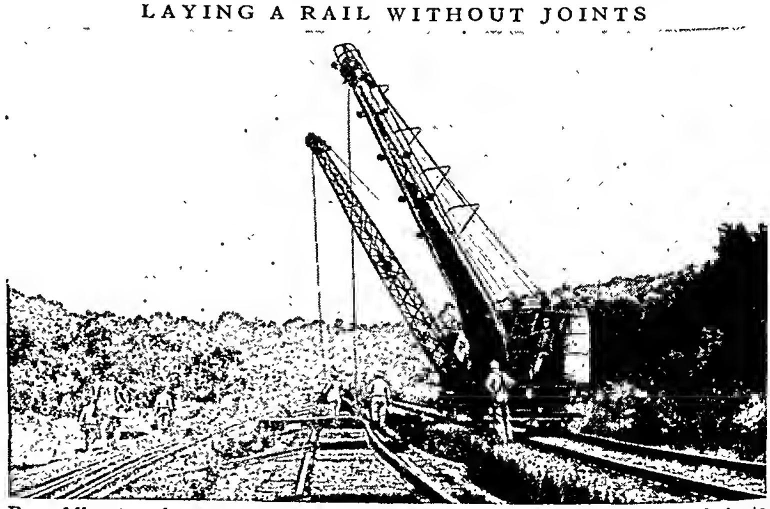
Standard gauge is used also in Canada, Mexico, and on the island of Cuba, which is connected with the railroads of the continent by freight-car ferry. No other continent, however, has a comparable standardization. In Great Britain and on the continent of Europe north of Spain and west of Russia, standard gauge is used, largely as a result of British influence. In Ireland, however, the gauge is 5 feet 3 inches; in Spain and Portugal, 5 feet 6 inches; in Russia, 5 feet. China, Manchuria, and Korea use standard gauge, but in the rest of Asia there is wide diversity. India uses 5 feet 6 inches, one meter, and other gauges. Most trackage in the Near and Middle East is standard gauge. The Japanese gauge is 3 feet 6 inches, as is that of New Zealand. Australia has much mileage of that gauge as well as Irish and standard gauges. On the continent of Africa there are standard, 3 feet 6 inches, one meter, and 3 feet. South and Central America use more than six gauges, ranging from 2 feet to 5 feet 6 inches.

Developing Better Locomotives

While extending their lines, railroads were also developing better locomotive power, improved cars, and more efficient operating methods. The first ten years of railroading in the United States saw the development of the *American* type of locomotive. This became the ancestor of a long and varied line of freight and passenger types. The *American* was an eight-wheel locomotive, with a four-wheel leading truck and two pairs of driving wheels, coupled. Addition of a third pair of driving wheels created the *Ten-wheeler*. Like the *American*, it was an all-purpose engine designed for either freight or passenger service.

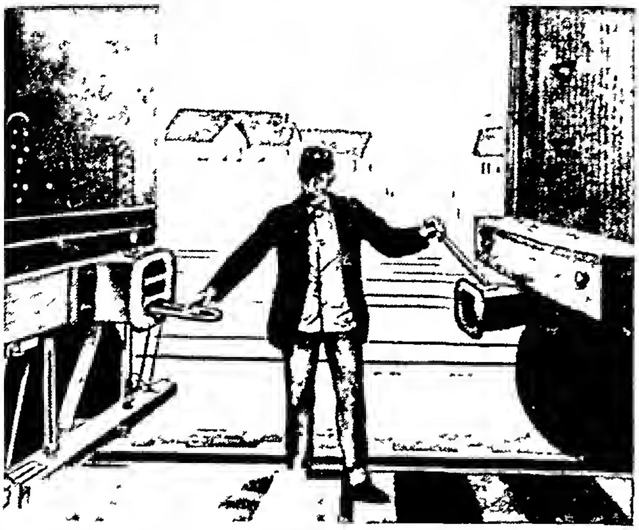
After the *Ten-wheeler*, wheel arrangements of locomotives intended for different classes of service developed differently. In freight service, the four-wheel leading truck was replaced by a single two-wheel leading axle to create the type known as the *Mogul*. Adding a fourth pair of drivers created the *Consolidation* type. In turn this type evolved into the *Mikado* by the addition of a trailing axle. This

LAYING A RAIL WITHOUT JOINTS



By welding together many short rails, as has been done here, railroads eliminate the joints that cause the familiar clickety-clack noise of train wheels.

HOW RESEARCH AIDED SPEED AND SAFETY



In the early days of railroading the slow and dangerous link-and-pin couplings were used to hold cars together in a train.

One of the biggest improvements in railroad equipment was the invention of the automatic coupler. This is the "E" type.

axle supported the larger and wider firebox needed to meet the demand for more power. A fifth pair of drivers distinguished the *Santa Fe*. The use of a four-wheel trailing truck (to support a still larger firebox) instead of a two-wheel trailing axle marked the *Texas* type.

Meanwhile, demands for still greater concentrated power brought the *Mallet* locomotive from Europe in the early 1900's. The *Mallet* is essentially two engines under one long boiler which supplies steam for both. The early *Mallets* were "compounds." In them the steam was first used at high pressure in small cylinders then exhausted into large cylinders where it was used again at low pressure. The need for greater speeds resulted in the "simple" *Mallet*, in which steam is used at high pressure in all four cylinders. The largest steam locomotives ever built were of this type.

With the evolution of the freight locomotives there was a parallel development of passenger power. The four-wheel leading truck was retained on almost all passenger types. The addition of a larger firebox, carried on a trailing axle, made the *American* into the *Atlantic*. A similar addition to the *Ten-wheeler* created the *Pacific*. Adding a fourth pair of drivers to the *Pacific* created the *Mountain* type. Finally, the addition of a four-wheel trailing truck to carry a still larger firebox made the *Mountain* into a type variously named but most commonly known as the *4-8-4*, with four small wheels in front, eight driving wheels, and four small wheels behind. The *4-8-4*, like the *American* and the *Ten-wheeler*, which were the common ancestors of all locomotives, was developed as a dual-purpose engine. It had power enough for fast freight service and speed enough for heavy passenger service.

At the same time special engines were being developed for switching service. These did not need either leading trucks or leading axles, such as were required on road engines, and did not need the high sustained steaming power which called for extra-large fireboxes. Thus the switcher type put all its weight, and hence all its driving power, on small close-coupled drivers.

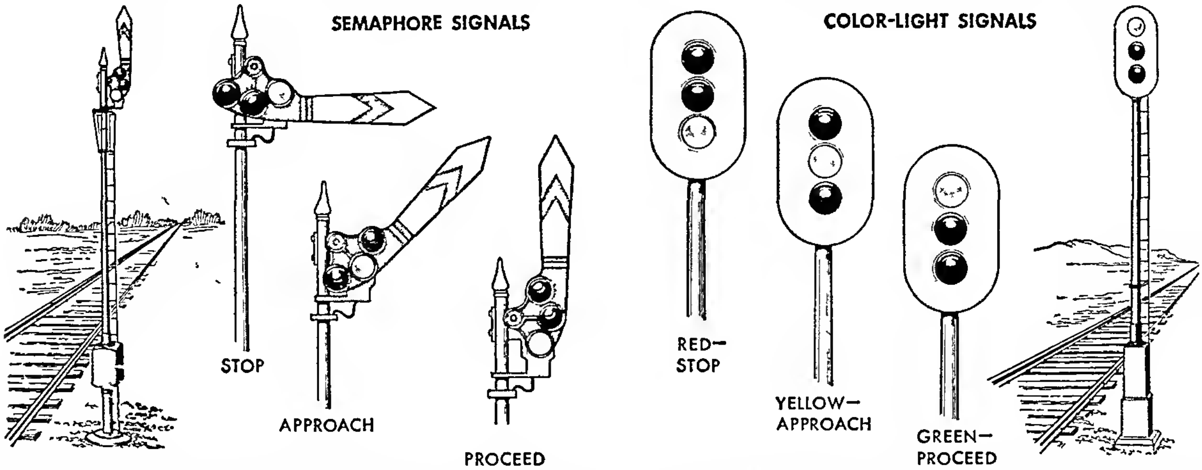
Modifications in wheel arrangements indicate only some of the changes in the steam locomotive. Better ways to make steam and better ways to control and use it at high temperatures brought the locomotive from the tiny "teakettle" of eight or ten tons to giant units weighing as much as 500 tons. These giants can produce as much as 7,000 horsepower and are capable of pulling mile-long trains at a mile-a-minute speed. (*See also* Steam Engine.)

Use of Electric Power

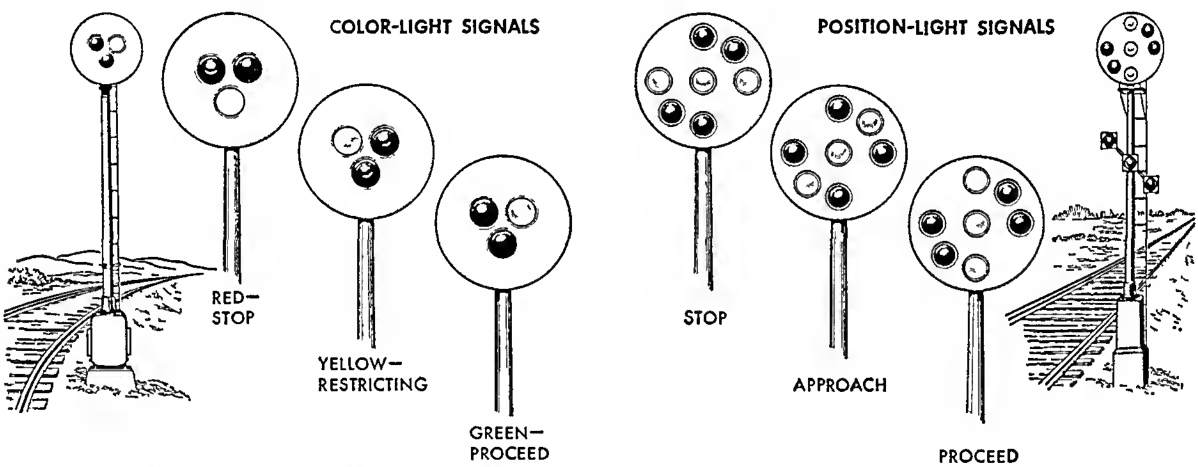
In 1895 electric locomotives were introduced. These drew their power from central generating stations through overhead wires or charged third rails. The first use of such power was in a long tunnel under the city of Baltimore; and most of the early uses were confined to difficult tunnel or terminal locations where steam locomotion was impractical. Central-station electric locomotion made possible such developments as the Pennsylvania Station and Grand Central Terminal in New York City, the underwater tunnels under the Detroit River, and the intensive development of zones of electrified suburban service around New York City, Philadelphia, and Chicago. (*See also* Street Railways.)

Central-station electrification has not been widely used for over-the-road service in the United States. Its main use is in areas of high density traffic such as between New York City and the cities of Washington, D. C., Harrisburg, Pa., and New Haven, Conn. It is also used on the Virginian Railway in the Allegheny Mountains and on the Milwaukee Road in the Rocky Mountains and the Bitter Root Mountains. In those European countries where fuel is scarce and hydroelectric power is plentiful, central-station electrification is relatively more widely used than in many areas of the United States.

WAYSIDE SIGNALS FROM TOWERS ALONG THE TRACKS



When a train approaches a wayside signal tower, the signal automatically indicates to the engine and train crews the present use of the block ahead. The position of semaphore arms (left) gives a signal by day; colored lights give it at night. The vertical color-light signals (right) flash their message through colors—red, yellow, green—both day and night.



Color-light signals may also be arranged triangularly (left). The position-light signals (right) tell their message by the direction of a line of lights of the same color, as modified by the lights on the arm below. Each signal given by colored lights indicates one of three messages: stop; approach, or restricting (reduce speed); or proceed at authorized speed.

American railway electrification has progressed in another fashion through the wide adoption of the diesel electric locomotive. This generates its own electricity as it goes along and thus needs no outside facilities for power distribution. The diesel was first used in switching service in 1925. In 1934 it was used to power one of the first streamlined trains. It was introduced in heavy road freight service in 1941. World War II delayed further adoption, but with the close of the war the change to diesel power was swift. By the 1950's about three fourths of all railroad service was being performed by diesel locomotives. Most of the engines had been put in service after the war's end. (*See also* Diesel Engine.)

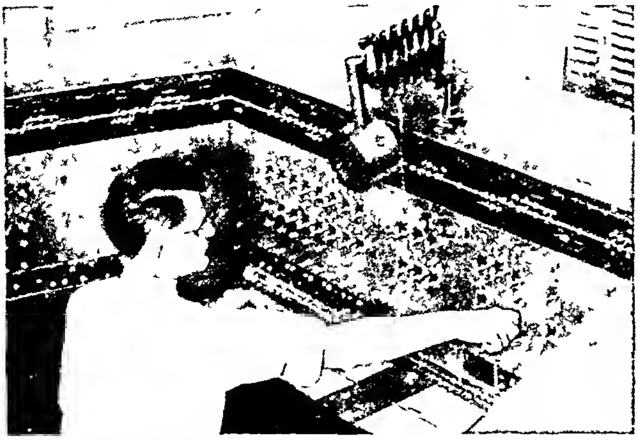
In the same postwar years still another type of electric locomotive was introduced. This had a gas turbine that generated the power. Within a few years the Union Pacific had six such locomotives in service. These engines used low-grade bunker oil as fuel; others were developed to burn finely powdered coal. (For diagram of the gas turbine, *see* Internal Combustion Engine.) Another development was a coal-burning steam turbine locomotive with electric drive.

Operating Cars in Trains

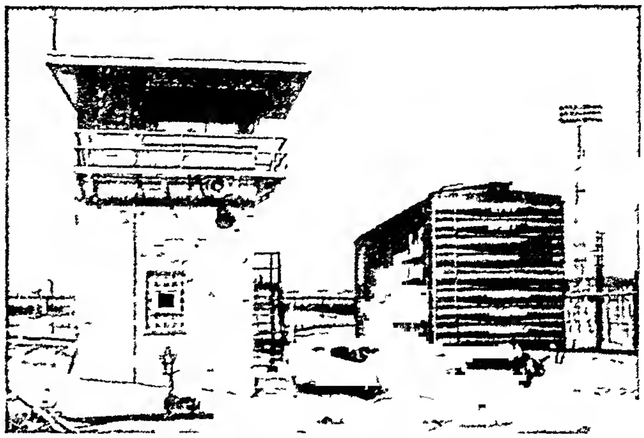
Besides track and locomotives there is a third basic element in railroading—cars in trains. Cars combined into a train and operated as a unit need some means of coupling and uncoupling, of absorbing the push and pull of cars working together, and of applying and releasing brakes. All such means were lacking on the early cars. The earliest freight cars were simply boxes mounted on flanged wheels. For passenger trains, stagecoach bodies were similarly mounted.

Early inventors were busy with devices for quick, simple coupling of cars. The link-and-pin coupler soon came into use, but it was dangerous because a man had to go between moving cars to couple and un-

CONTROLLING TRAFFIC ON THE ROAD AND IN THE YARD



From this centralized traffic control board the operator can direct all the trains along several hundred miles of track.



This car is coasting down the hump in a freight yard. A tower operator switches it onto the proper track.

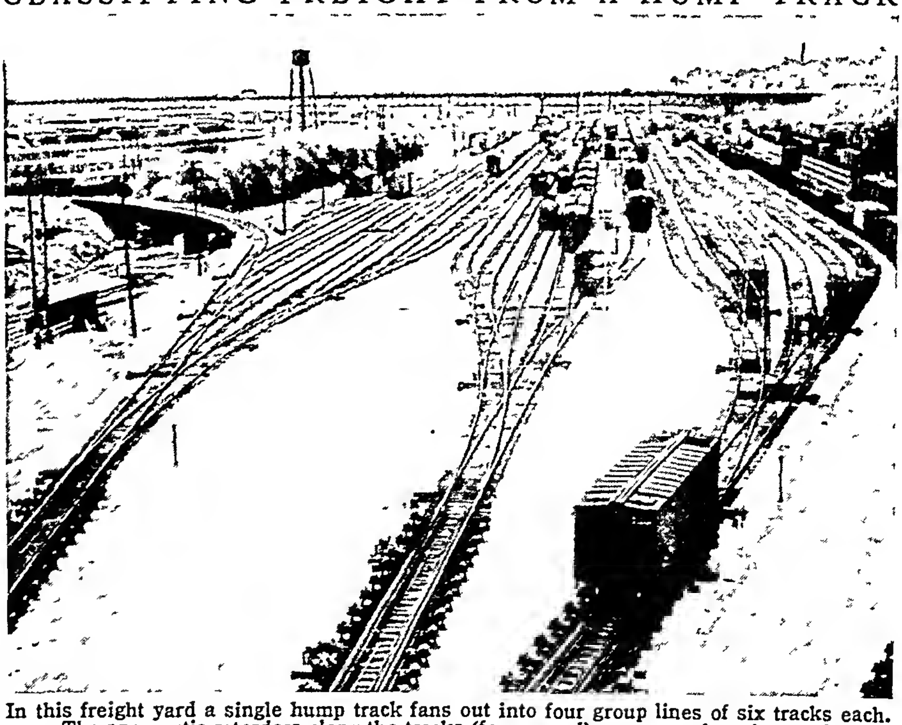
couple. Numerous patents were issued for "safety" couplers designed to avoid this danger. It was easy to develop an automatic coupler which would work with another like itself, but this did not answer the problem. The new coupler had to be one which could work with those already in use during the transition period. More than 40 different designs were tried out by the Master Car Builders (one of the predecessor organizations of the present Association of American Railroads). Finally the design of Major Eli H. Janney was adopted in 1887. No longer did a man have to go between the cars to pull out or drop in the pin. Vastly improved in detail, the idea of the Janney coupler remained basic in the series of uniform standard couplers adopted since that time. The standard coupler also works with the newer tight-lock couplers, which reduce the free and uncontrolled slack between cars.

Merely coupling cars together is not enough to enable them to be operated as a unit. There must be some way to absorb and dissipate the shocks between cars as they run coupled together in trains. To do this, various forms of *draft gear* are installed between the couplers and the underframes of the cars. In America draft gear is designed to absorb both push and pull. In Europe the automatic coupler is not used widely; connection between cars is usually made with a hand-operated turnbuckle and screw. On cars so equipped, the pushing shocks are usually absorbed by projecting buffers.

Stopping trains quickly, smoothly, and safely was studied from the first days of railroading. The problems were difficult, for it takes as much power to stop a train running 60 miles an hour as it would to lift the same train to the top of a ten-story building.

Many complicated braking devices were tried with indifferent success. In 1868 George Westinghouse invented the air brake. In it, compressed air controlled from the engine put on the brakes. It was a tremendous advance, but its defect was that it was necessary to increase the air pressure to apply the brakes. Four years later, Westinghouse devised the automatic air brake. His new brake maintained constant air pressure when the train was in motion. Decreasing the pressure caused the brakes to be applied. How it works is shown in a diagram in the article on Brakes. (*See also* Westinghouse.)

CLASSIFYING FREIGHT FROM A HUMP TRACK



In this freight yard a single hump track fans out into four group lines of six tracks each. The pneumatic retarders along the tracks (foreground) govern each car's speed.

Installed first in passenger trains only, the air brake was perfected for use in freight trains as long as 50 cars by the mid-1880's. Since then it has been continuously improved. In prospect for freight service is a brake which automatically varies its pressure according to the weight load on its car. Some passenger car brakes may be applied by electric controls as well as by air pressure.

Operating Many Trains at Once

Railroads have intricate systems to govern the use of tracks by trains of different classes moving in different directions and at different speeds. On some of the earliest horse-drawn railroads, these arrangements were simple. *Halfway posts* were set up at the midpoint between turnouts or sidings. The team which reached the halfway post first had the right of way to the next turnout; the oncoming team had to back up. The coming of the locomotive brought both a crude signal system and a more elaborate system of operation by timetable. The signal system consisted of a colored ball which could be hoisted to the top of a pole beside the track. When at the top, it meant that the way was clear—hence the railroad term *highball*, meaning "go ahead."

The *timetable* system was more popular. The table told when each train was due at each station and which class of trains had the right of way over other classes. The timetable could not, however, account for extra trains or for irregularities which often required a train to wait long periods for an overdue "superior" train.

One such experience in 1851 led Charles Minot, superintendent of the Erie Railroad, to take the next step in train operation. Using the newly installed telegraph line, he wired ahead to the next station to hold up an oncoming "superior" train which had been delayed and then gave the "go-ahead" signal to an "inferior" train. Telegraphic train orders along with the basic timetables soon came into almost universal use. Later the telephone largely supplanted the telegraph in the transmission of train orders.

The basic idea of the timetable and train order system was to keep trains separated by intervals of time. The protection of another system was soon added—separation by an interval of a space, or *block*. A block may be any distance from a few hundred yards to several miles. Early block systems depended upon manual operation to signal approaching trains whether the block ahead was occupied or clear. Manual block is still used on lines of light traffic density. In 1871 William Robinson devised the closed electric track circuit, which became the foundation of the automatic block system. The automatic block system, developed over the years, is used on most of the heavier traffic lines.

Under this system, the presence of a train in a block acts on the electric current in the rails. The current sets up signals in at least two blocks ahead to warn approaching trains. These warnings are indicated by the position of semaphores or by the color or position of lights mounted on masts or bridges alongside or above the tracks. Thus each train automatically and without any further human help operates its own warning signals and sets up its own zones of protection. Electronic improvements include *cab signals*, in which signals are repeated inside the cab before the eyes of the engineman and fireman; and the *automatic train control*, in which brakes are automatically applied if the engineman should accidentally run by a stop signal.

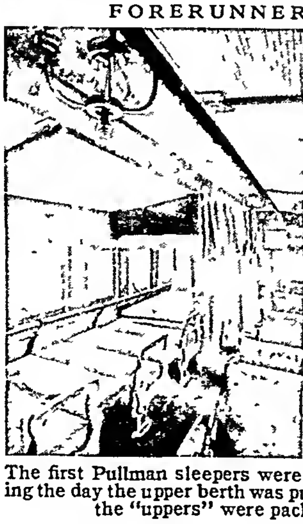
Another widely used system is *centralized traffic control* or, in railroad language, "C.T.C." With this system each train automatically reports its position and movements through electric lights on a track map in front of the control operator. With this information before him, the operator arranges train movements with minimum delay and interference. He issues orders for such movements merely by setting signals at passing tracks, some of them hundreds of miles away. He can also throw switches at these tracks. The system is so interlocked that it is impossible to have the signal give an indication that is contrary to the position of the switch. With C.T.C. almost as much traffic can move over a single-track as over a double-track line.

Railroads also use radiotelephone and an induction system which employs rails and wayside wires as carriers of message currents. With these, messages can go between the front and rear of a train, between train and train, and between moving trains and wayside stations.

Push-Button Railroading

The various systems for sending orders and information by wire and radio are most intensively used at major railroad terminals. These modern terminals are aptly called "push-button yards." Here the work

FORERUNNERS OF MODERN SLEEPERS



The first Pullman sleepers were constructed from day coaches (left) in 1857. During the day the upper berth was pulled up to the top of the car on pulleys. By the 1880's the "uppers" were packed away in cribs near the ceiling (right).

is done with only a relatively few men and switching engines. In such yards a switching engine pushes incoming trains over a small hill, or *hump*. As each train moves slowly past, cars are cut off and allowed to coast down toward tracks where new trains are being made up for different destinations. As they roll down the hill, a man in a control tower throws the switches that turn them into their proper tracks. He also controls their speed, using electropneumatic *car retarders* which squeeze the edges of the wheels against the rails.

Thus a train coming in at one end of the yard is broken up and its cars distributed into new trains for different destinations without backup movement of any kind. The information needed to switch the train is sent ahead of its arrival, either by teletype from the previous terminal or by pneumatic tube from the entrance track. Information is swiftly recorded by photography so that the steady forward progress of the cars is not delayed. Information is often transferred to punch cards which are run through machines. These record the appropriate information and sometimes transmit it automatically and instantaneously to the next terminal ahead.

Communication between switching crews and yard offices takes place by two-way radiotelephone or by loud-speaker and *talk-back* installations at various points in the yard. Television is being used experimentally to bring into the central terminal office an actual view of operations at critical points.

Interlocking has had a great part in the development and operation of major terminals. It originated at points where one railroad line crossed another, and it is still widely used at such places to make it impossible to display signals which would give a "clear" indication on both tracks. In the more elaborate terminal installations, trains report their positions automatically on a terminal map in front of the towerman, or operator. He then sets up a route through the terminal for each approaching train. Interlocking makes it impossible to set up routes which conflict. In more recent installations, the operator only has to throw the lever for the entrance and exit points. The machine sets up the entire route, throws all switches, and sets all signals through the maze of tracks.

INCREASING THE PLEASURES OF TRAVEL

During the 1950's some passenger cars were constructed with an observation dome running the entire length of the car.

These interlocking arrangements reach their highest development in the tracks leading into large passenger stations. These may have 50 tracks and many times that number of route combinations reaching them. Over these routes move as many as 600 trains daily with heaviest traffic at rush hours.

Serving Passengers and Shippers

The railroads offer three basic types of passenger service: *commutation*, *local*, and *through*. Commutation service is provided for people who live in suburbs and work in nearby cities. Commuter passengers usually buy multiple ride tickets. Local service trains stop at nearly all stations on their routes to serve passengers who ride for only a stop or two.

Through, or express, trains operate between larger cities with few or no stops at smaller towns in

MOST OF THE COMFORTS OF HOME

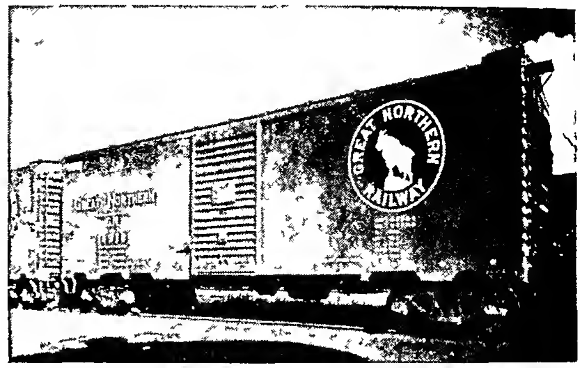
Today passengers can eat three meals a day in attractive dining cars (left) featuring air conditioning and indirect lighting. These "day-night" coaches offer all the comforts of a living room (center). A modern bedroom (right) offers passengers privacy and conveniences. Contrast this sleeper with the reconstructed day coaches of a hundred years ago (opposite page).

between. Some of these trains provide conventional coach accommodations similar to those on commuter and local trains. Some trains have reserved coach seats. *First-class* fares permit the traveler to ride in roomier parlor and Pullman cars. Some Pullman cars have open seats for daytime travel; these are converted to upper and lower berths at night. Other Pullman cars are divided into rooms of various sizes.

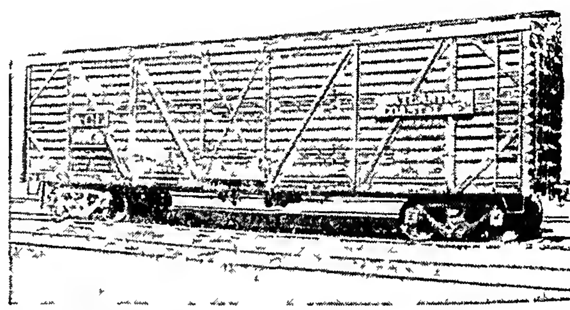
Extra-fare trains have Pullman accommodations but charge a little more because of their speed. Special *excursion* trains carry passengers all bound for the same destination, such as a convention city or a ski resort. Some railroads offer *family travel plans*—lower rates to a family traveling together—usually during the first half of the week when business is lighter. *Round-trip tickets* are sold at reduced rates. Passenger fares normally make up only about one sixth of the railroads' total revenue.

Freight rates provide most of the railroads' income. Nearly all freight moves under *commodity rates* established for specific commodities which are shipped from one specified place to another. *Classified rates* govern the shipment of commodities grouped into classifications. All items within one classification are shipped at the same rate. *Classification exception rates* are for certain commodities which have been removed from their classifications in order to give them lower rates. Within each type of rate there is one charge per hundred pounds for *carload shipments* and a higher charge for *less-than-carload* (*L.C.L.*) *shipments.*

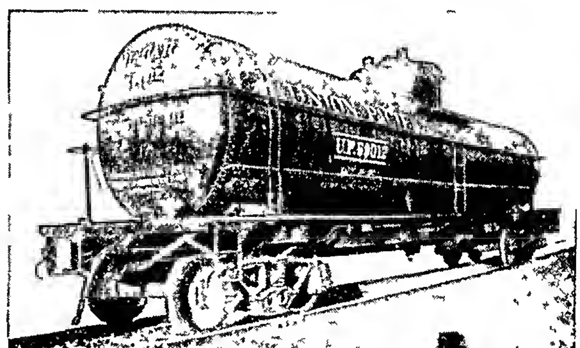
THREE WAYS OF HAULING FREIGHT



Steel boxcars provide cheap, weatherproof hauling of freight. A car such as this one can carry a load up to 100,000 pounds.



A standard 36-foot stock car can carry as many as 25 horses or heavy cattle; or with two decks, 120 to 130 hogs.



Tank cars have been used to transport oil since 1865. The average tank car can carry more than 12,000 gallons.

Railways of the World

Throughout the world there are about 780,000 miles of railroad line (mileage of first main track, excluding additional main tracks, sidings, terminal tracks, and others). Of this total 225,000 miles are in the United States, 43,000 miles in Canada, 12,500 miles in Mexico, 2,000 miles in Central America, and 3,000 miles in Cuba, making a total of about 285,500 miles in America north of the Isthmus of Panama. There are about 263,000 miles in Europe, 95,000 miles in Asia, 62,000 miles in South America, 43,000 miles in Africa, and 31,500 miles in Australia. (*See also* **Railroad Mileage** table in FACT-INDEX, and Fact Summary for each state.)

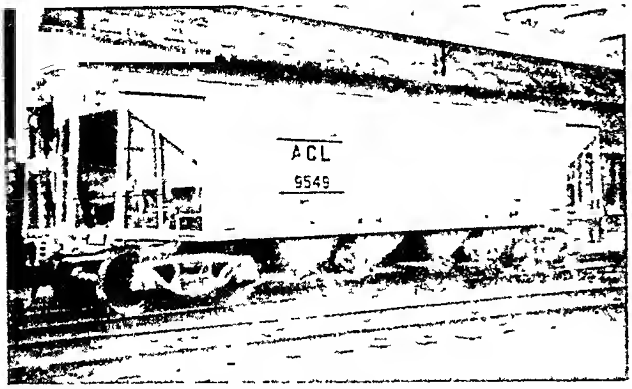
More than half this mileage is owned by governments and operated by a government agency or through a government-owned corporation. Most of the world's privately owned mileage is in the United States, where virtually all railroad operation is by private companies. In Canada, the Canadian Pacific line is privately operated, and the Canadian National is run by a government-owned corporation.

Railways of the United States

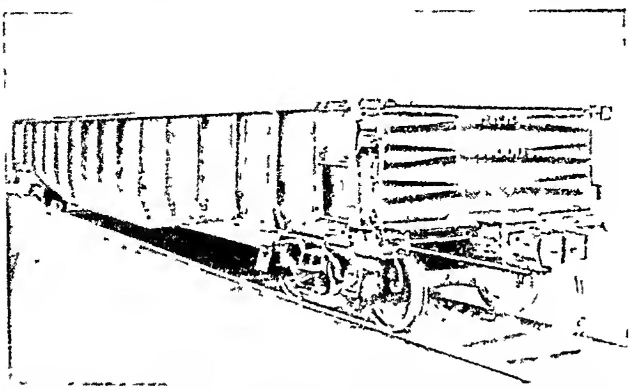
In the United States railroad operation is carried on by nearly 700 different companies. Of these, 133 railroads are classified by the Interstate Commerce Commission as *Class I*. This means that these roads have gross operating revenues of more than one million dollars a year. Of the remainder, 345 are smaller line-haul railroads and 213 are switching and terminal companies, performing services for two or more line-haul companies. On about 28,000 miles of line (encompassing a considerably greater mileage of all types of tracks), trains of more than one railroad are operated under arrangements usually known as *trackage rights*. Here the owning company permits one or more other companies to use its line.

Many operating companies do not own all their lines. They lease portions of them, paying rent to the owners. Some of these owners are public bodies, such as the state of Georgia, which owns a line between Atlanta and Chattanooga, and the city of Cincinnati, which owns a line between that point and Chattanooga. Both lines are leased to private operating companies. During the early days of railroad-

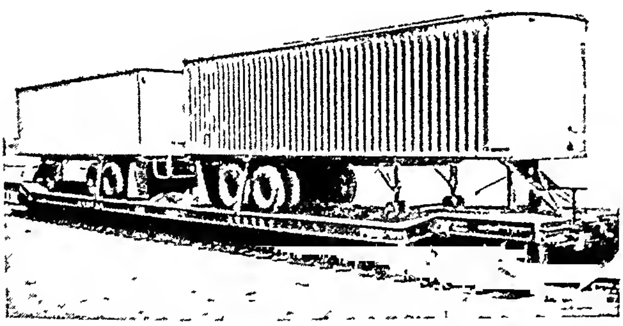
OTHER WAYS OF HAULING FREIGHT



There are more gondola, or hopper, cars used than any other kind (about 800,000). This one can carry 140,000 pounds of phosphaie.



This type of gondola is the open car for carrying freight such as coal, which leads all commodities in tonnage and carloadings.



Illustrating the co-operation between railroads and trucking lines is this modern flatcar designed to carry two huge truck trailers.

ing in the United States a number of states and eities built and started to operate railroads. Today, with the exeeption of a few terminal lines, all such lines are either abandoned or leased to operating railroads.

At one time there were about 6,000 railroads in the United States, nearly ten times the present number. A few of these early lines have been abandoned, but most of them have gradually been absorbed into larger systems. Some of the modern railroads include the former property of hundreds of early companies.

This proeess of loeal lines eoming together to form larger systems had determined the main shape of the railroad network by 1890. In that year the Sherman Anti-Trust Act was passed; the act slowed down the proeess of eonsolidation. This policy was reversed and consolidation eneouraged by the Transportation Aet of 1920. Today consolidation is left largely to the railroads themselves, subject to the approval of the Interstate Commeree Commission.

How a Railroad Is Organized

The organization of a typieal operating railroad eonsists of the stoekholders, who own the property; the board of directors, whom they elect to supervise its policies; a president, elected by the board of direetors to be its ehief exeeutive officer; and a staff of offieeis and cmployees working under his direetion.

About 90 per eent of the employees work in the *operating department* under the direetion of a vieepresident. The operating department has three main funetions: *maintenance of way*—that is, maintaining the roadway, tracks, bridges, signals, stations, and stiuetures; *maintenance of equipment*—keeping locomotives, cars, and other equipment in proper running order; and *transportation*—handling freight and transporting and delivering passengers, mail, and express. On most roads these three functions are earried out under the direction of a *ehief engineer*, in charge of way and structures; a *ehief mechanical officer* (or some similar designation) in charge of ear and locomotive repair; and a *superintendent of transportation.*

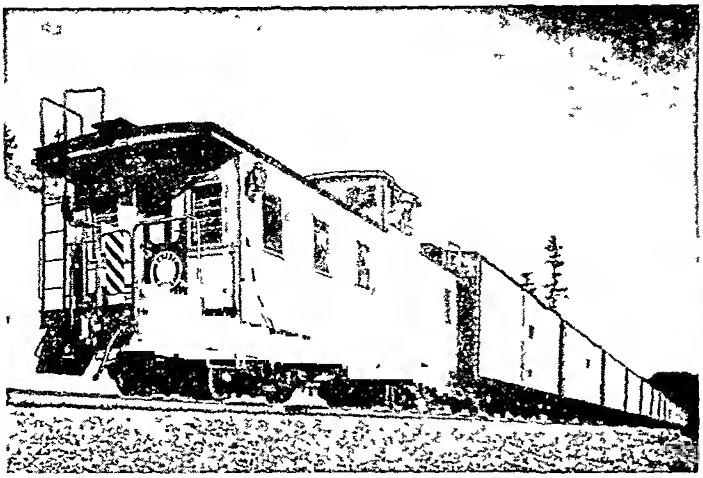
On most roads the line is subdivided geographically into regions, districts, or divisions. Commonly the *division* is the basic operating unit. In fact, it is like a small railroad in itself, with a *division superintendent* corresponding to the ehief operating offieer and a *division engineer, master mechanic,* and *trainmaster* in charge of the three major operating funetions.

Of the approximately 1,200,000 railroad workers in the United States, all but about 120,000 are in the operating departments. About 130,000 are engaged in over-the-road transportation serviee, and nearly the same number in making up and switching trains in yards and terminals. Maintenanee-of-way workers number about 235,000; shop workers, about 320,000. The remainder work as station agents, telegraphers, signalmen, towermen, watehmen, and on other jobs.

Another major department is the *traffic department,* in eharge of making the rates and selling the freight and passenger serviee. The *accounting department* keeps the books, audits the aeeounts, and eompiles statisties. The treasurer, or *finance department,* is responsible for the handling of the eompany's eash and securities. The *purchases and stores department* buys stores and issues materials and supplies.

Railroads were among the first industries to adopt colleetive bargaining between management and employees as a general praetiee. The great majority of railroad employees are members of one or another of the 22 "standard" *railroad labor unions.* Five of these unions form the so-ealled "operating" group, representing the engineers, firemen, eonduetors, trainmen, and switehmen who run the trains and work

A TRAIN CREW'S OFFICE ON THE ROAD

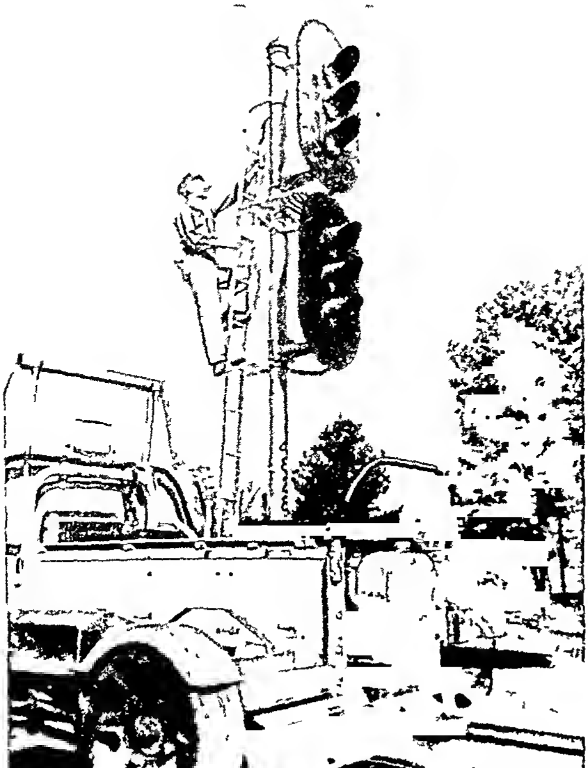


The rear car of a freight train has been called a "caboose" since about 1855. The observation perch (left) was introduced about 1863 on the Chicago and North Western. In the plywood caboose (right) a conductor and flagman check their reports on the move.

in the yards. The other unions represent the "nonoperating" workers, including office and station employees, track and shop workers, telegraphers, signalmen, and others. (*See also* Labor.)

Nonoperating employees and operating men engaged in yard service are generally paid on a basis of time worked. Men in train and engine service over the road are paid on a "dual" basis. This is essentially a piecework arrangement; pay is based primarily on miles run, with certain adjustments for the time required to make the prescribed runs.

CONSTANT MAINTENANCE IS REQUIRED



To insure safe yet speedy travel railroad equipment such as this color-light signal must be kept in perfect working order.

Interrailroad Arrangements

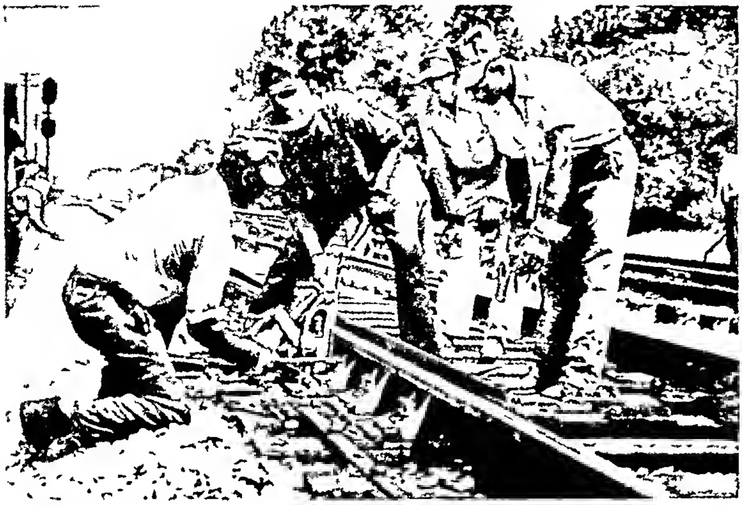
Perhaps the most familiar example of interrailroad arrangements is the through passenger train that runs over more than one line of railroad. Through trains between Chicago and Florida may run over six separate lines. Most trains between Chicago or St. Louis and the Pacific coast operate over two or three different railroads. The international trains between Washington, D.C., and Montreal and between Boston and Halifax run over four railroads Through car service between St. Louis and Mexico City runs over three lines. Through cars between the Atlantic and Pacific coasts are operated over numerous different combinations of lines.

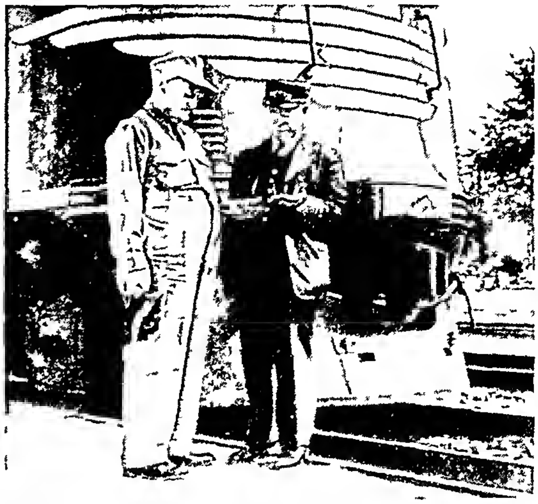
International railroading is more common in Europe. Through trains are operated among most of the countries of the continent, except where break of gauge, as at the Pyrenees, or political conditions make such operations impossible. Through sleeping cars run between Scandinavian countries and the rest of the continent by means of ferries across arms of the Baltic Sea. The international movement of freight is governed by detailed regulations, with certain equipment assigned to international service among the governments concerned.

The freight service of North America has the world's most comprehensive system for interchange of cars among railroads. Cars of any railroad in the United States, Canada, or Mexico may be seen in the trains of any other railroad. Any shipper in North America can load a car for delivery at any other station on the continent.

Standardization of track gauge is vital to interchange service, but much more is needed. Any one of the more than 2 million freight cars must not only couple with any other, but its brakes must work as part of the brake system of the whole train. Each railroad decides upon its own standards for its fixed plant—for example, the strength of bridges, the

TWO VIEWS OF "WORKING ON THE RAILROAD"





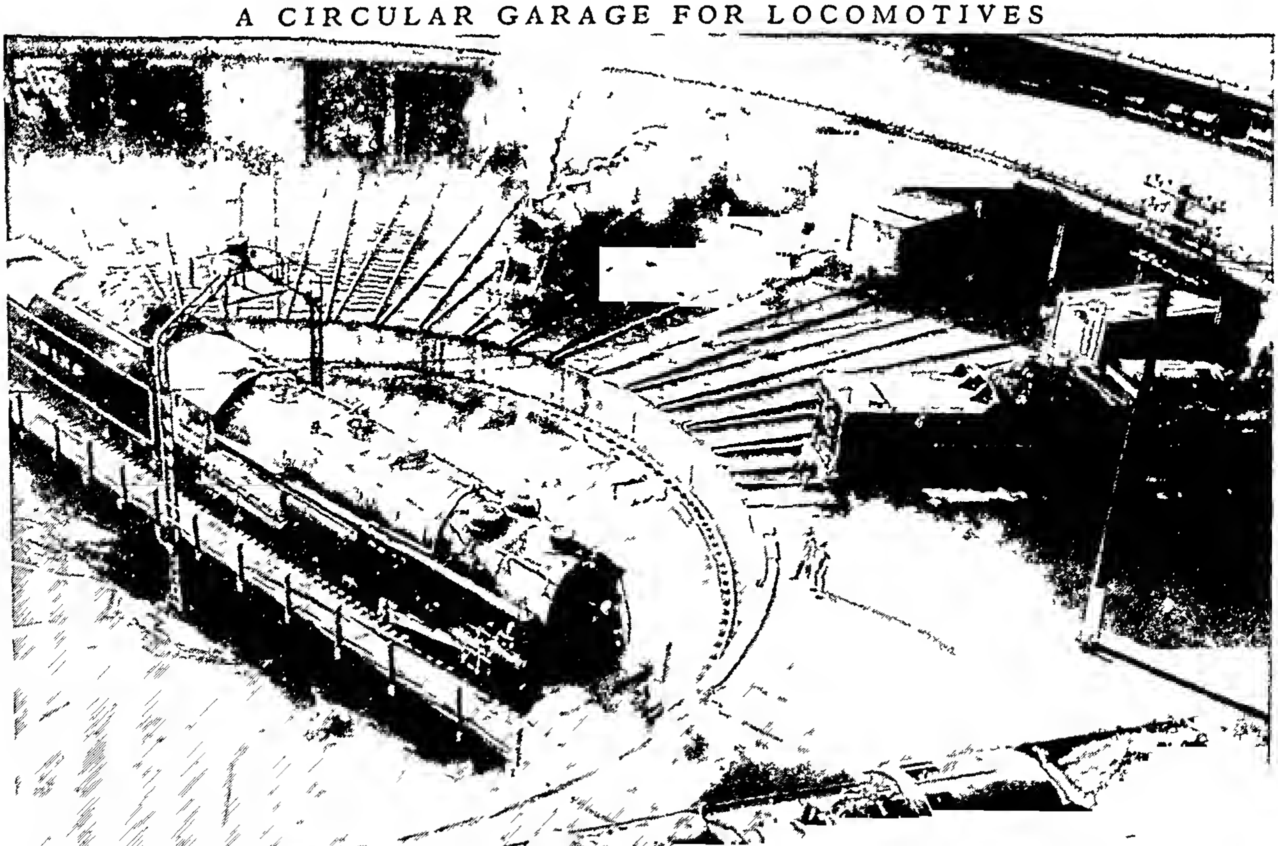
Keeping the tracks and roadbed in good running order is the job of section crews (left). Accurate time is vital to railroad operations. An engineer and conductor (right) perform the traditional act of checking their watches before starting a run.

nature of track structure, and the kinds of signals it uses. All freight cars, however, are built to meet certain standards agreed upon by all railroads. Thus any car meeting interchange standards set up by the railroads through the Association of American Railroads can go anywhere in any train of any railroad.

Getting Freight Cars "Home"

Physical standardization is only the first step in interrailroad arrangements needed to maintain the free flow of freight all over the continent. Freight cars must be sent back to their owning, or "home," lines from the "foreign" lines on which they travel. They must be kept in repair away from home. Joint through rates must be set up and collected, and the proceeds must be distributed among the railroads which took part in hauling the freight. Claims for losses and damages must be investigated, and the cost of settlement prorated among the participating lines.

A CIRCULAR GARAGE FOR LOCOMOTIVES

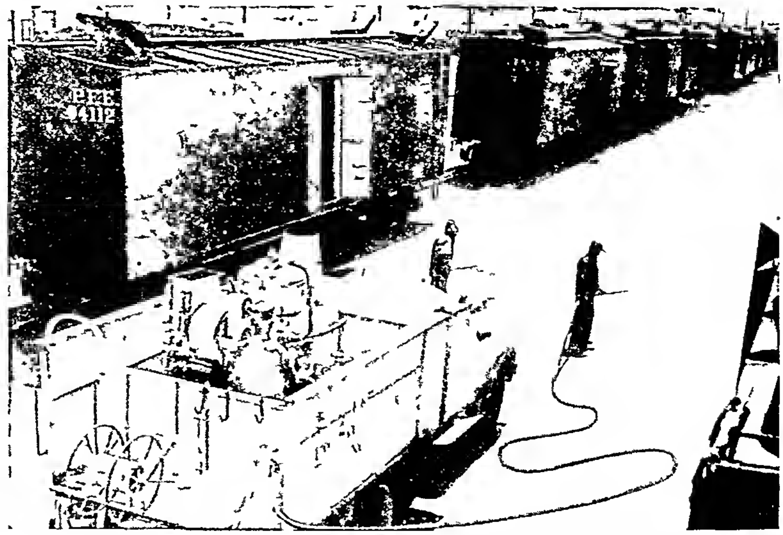


At the end of a run locomotives need inspection, cleaning, and sometimes repairs. In this roundhouse the locomotive is driven onto a huge turntable. From here it can be shunted into any one of the short tracks, or "stalls," for necessary work.

One basic rule provides for getting cars home from "foreign" lines. When a car is emptied it must be sent back to, or toward, the owning line. It can carry a load if one is available; otherwise it travels empty. The railroad on whose tracks the car is standing or moving must pay the owning line a "per diem," or daily rental charge, whether the car is loaded or empty. This charge, based on the average cost of car ownership, was for many years one dollar a car per day. By 1952, reflecting the increased cost of ownership, it had increased to two dollars a day.

Ordinarily railroads keep freight cars moving back to their owners. In times of extra demand—for example, the oncoming of a huge harvest or an emergency, such as a flood—the flow of cars can be directed to meet the particular need by the Car Service Division of the Association of American Railroads.

DEFROSTING AND CLEANING REFRIGERATOR CARS



Like home refrigerators, railroad refrigerator cars must be defrosted and cleaned. The hot spray from this portable steam generator can melt 125 tons of ice a day.

Other Types of Co-operation

The greatest pool of passenger cars is that operated for the railroads by the Pullman Company. This company, founded by George M. Pullman just after the Civil War, finally came to own most of the sleeping cars and parlor cars in the United States, as well as some in Mexico and Canada. It operated them under contracts with the different railroads over which the cars ran. Most Pullman cars were built by an affiliated company; this and the operating company were under common ownership. When the common owner was required under the antitrust laws to dispose of one or the other. it elected to keep the car manufacturing company. It sold the operating company to those railroads which offer sleeping car and parlor car service to their passengers. Most sleeping cars and parlor cars are now owned by the railroads but are serviced and operated by the Pullman organization

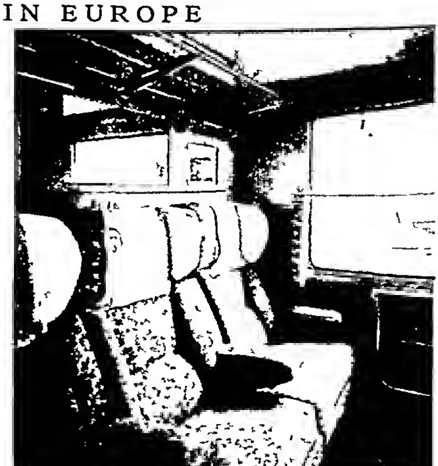
In Canada most of these cars are operated directly by each railroad. In Europe there is both individual railroad operation and also a great amount of international operation under the direction of the *Compagnie Internationale des Wagons-Lits.*

Another major joint operation of the railroads is the *Railway Express Agency*, which provides speedy service for handling packages, usually on passenger trains. It also has one of the world's largest fleets of motor vehicles. Under special contract with the commercial airlines, it provides the collection, delivery, and other ground services needed for air express. (*See also* Express.)

Government Regulation of Railroads

Because they are common carriers, serving the public, railroads have been subject to governmental regulation since early times. For example, many early

A FIRST-CLASS RAILROAD IN EUROPE



In France, the largest lines are part of the state-owned French National Railroads. At the left is the 'Golden Arrow,' an overnight train between Paris and London, leaving the Paris station, the Gare du Nord. At the right is a first-class compartment.

charters specified the maximum rates and fares that might be charged, the maximum return on investment that might be earned, or both. Some early railroads, such as those in New York, Pennsylvania, and Ohio, were prohibited from carrying freight in competition with state-owned canals. If they were permitted to do so, they had to pay tolls which would have been collected had the freight moved by canal.

In the 1870's and thereafter came the so-called "Granger" movement for more detailed regulation of railroad rates and practices by state laws. Such regulations proved comparatively ineffective because most of the traffic was interstate and therefore not subject to state laws.

In 1887 Congress passed the original *Interstate Commerce Act*. With numerous amendments, this continues to be the basic act to regulate interstate commerce moving by rail and to some extent that moving by highway, pipeline, and inland waterway. The railroads are also subject to regulation by the state commissions which have jurisdiction over matters of state and local concern. (*See also* Interstate Commerce Commission.)

During World War I the government operated the railroads for a period of 26 months. There was no move for government operation of railroads during World War II. At other times the president of the United States has taken over the railroads for brief periods of government operation to prevent a complete tie-up due to unsettled labor disputes.

The Pace of Progress

Railroad traffic has reached record volumes since World War II. During the postwar period the railroads carried forward an improvement program costing more than a billion dollars a year. This money bought better power, tracks, signals, terminals, and other facilities. From these came more adequate and dependable services, provided at lower cost.

During the long history of American railroading such an improvement program has taken place many times. Heavy capital investment has made possible lower costs, which in turn have led to lower charges. In the 1840's, for example, the average revenue from moving one ton of freight one mile was about six or seven cents. Thirty years later, invention and improvements brought this figure down to about three cents. By about 1900, it was less than one cent. The 20th century, with its two World Wars, brought increased wages, prices, taxes, and other costs. Rate increases were necessary, and the average revenue from hauling one ton for one mile rose to about one and a half cents by the 1950's.

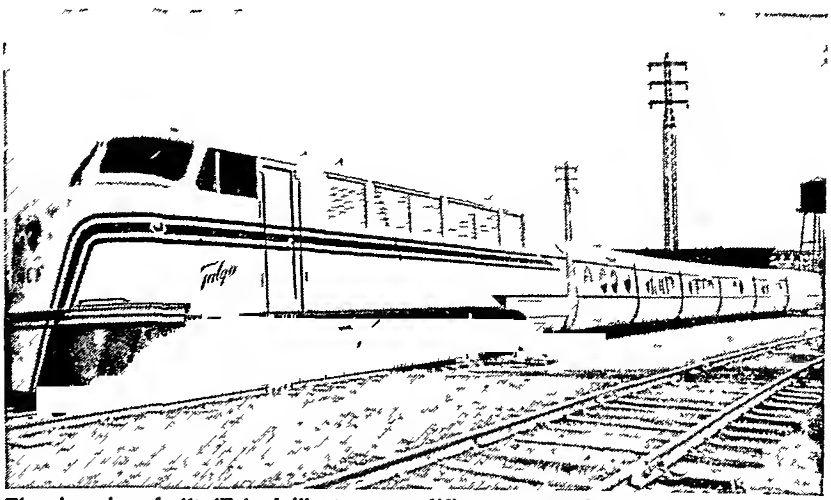
The accelerated pace of railroading science has helped hold railroad charges down. New designs, materials, methods, and general improvements in service have been fitted into the familiar pattern of railroading. Since World War I, for example, advances have included diesel locomotives, lightweight streamlined cars, air-conditioned passenger cars, centralized traffic control, automatic train control, push-button yards, train telephones, and a host of other developments.

The effect of all these improvements cannot be measured in any one figure or in any group of figures. Perhaps the best single yardstick available is the increase in the hourly output of transportation of the average freight train. In the early 1920's the average freight train turned out in one hour a service equivalent to moving less than 7,500 tons of freight one mile. Thirty years later, the hourly transportation output of the average freight train had increased to more than 22,500 tons per mile—three times what it had been 30 years before.

OPERATING MODEL TRAINS ON SCHEDULE

Model railroading can provide hours of interesting entertainment. To operate several trains at once requires split-second timing of a score of switches.

A RAILROAD TRAIN THAT HUGS THE RAILS



The American-built 'Talgo' illustrates a different type of train construction. Its locomotive is two feet and the coaches four feet lower than the standard types.

RAINBOW. According to an old story there is a pot of gold at the end of a rainbow. Nobody has ever found such a treasure because a rainbow is really a circle and therefore has no end. The bottom half, hidden from the observer, lies below the horizon. More important is the fact that a rainbow is really only colored light created in the sky when the rays of the sun strike falling raindrops. Rainbows are curved because the raindrops that reflect the light are themselves curved.

A rainbow occurs after a storm when the sun begins to shine while the air is still filled with raindrops. It is seen best when the sun is behind the observer and the falling mass of raindrops is to his front. This colorful spectacle is seen more often in the morning or in the evening. At noon the sun is so high that its rays cannot get underneath the edge of a rain cloud to strike the sheet of water. This is also the reason why rainbows occur more often in summer than in winter. In summer, showers are usually local so that while it is raining in one area, the sky is clear enough nearby for the sun's rays to emerge. In winter, rainfall is more widespread and the sun is entirely hidden from the observer.

The arcs of colors in a rainbow are caused by refraction (*see* Light; Spectrum). Each raindrop refracts (bends and separates) the sunlight into bands of distinct colored lights just as a prism does. Then the far surface of each drop reflects the bands of light back toward the observer. As the bands leave the raindrop they are again refracted. The result is the same as if colored beams from millions of tiny searchlights were flashing in the sky. There is a different set of light rays moving along different paths to each viewer; therefore no two people ever see exactly the same rainbow.

In *primary* rainbows the colors are arranged in the order of the spectrum—outside, or top, red; then orange, yellow, green, blue, and violet. (For picture in color, *see* Color.) Sometimes the edge of the raindrop toward the viewer reflects the light back through the farther edge. This forms a faint *secondary* bow seen against distant clouds. On these secondary bows the colors are reversed with red on the inner edge. In many rainbows one or more of the colors drop out, most often, blue. Red is almost always present. Some bows have blank white spaces or sometimes dark spaces between two layers of color.

The rare and beautiful lunar (moon) rainbow is formed in the same way as a solar (sun) rainbow. So are the little bows seen in the spray of waterfalls and lawn sprinklers. Halos around the sun or moon ("white rainbows") are caused by light shining through tiny ice crystals. Sundogs, colored patches on either side of the sun, are formed by flat hexagonal (six-sided) crystals falling through quiet air.

Many years ago men were puzzled by the rainbow and invented fables to explain it. The ancient Greeks imagined it was a sign placed in the heavens by the gods to foretell war or heavy rain. The Norsemen believed the gods used rainbows as a bridge between earth and their home in the sky. The ancient Hebrews thought the rainbow was a symbol of the Lord's promise never to destroy the earth by flood again.

RAINDROPS *That* WAKE *the* FIELDS *to* LIFE

RAINFALL. Farmers throughout the world depend upon rain for growing crops and raising livestock. Even where land is irrigated, rainfall furnishes the original water supply. Rainfall really means all *precipitation*—all the water that falls on an area, including rain, snow, sleet, hail, dew, and frost. Rainfall is measured in inches; one inch of rain fills a straight-sided gauge to a depth of one inch. It takes 10 or 12 inches of snow to equal one inch of rain.

In temperate climates, crops and livestock generally thrive if the yearly rainfall is 20 inches or more. Ten inches may be enough if it comes at the right season. The *effective* rainfall, however, is what counts. Rain is of no benefit if it quickly runs off steeply sloping land or sinks deep in porous soil. Likewise, rain that evaporates rapidly does not benefit farmers. Where high winds, tropical heat, or very dry air evaporate moisture quickly, more than 20 inches of rain a year are needed. Too much rain is harmful, however, for it erodes the land and dissolves (*leaches*) minerals from the soil. Rainfall around the world varies from more than 450 inches a year to virtually none (.05 inch at Iquique, Chile).

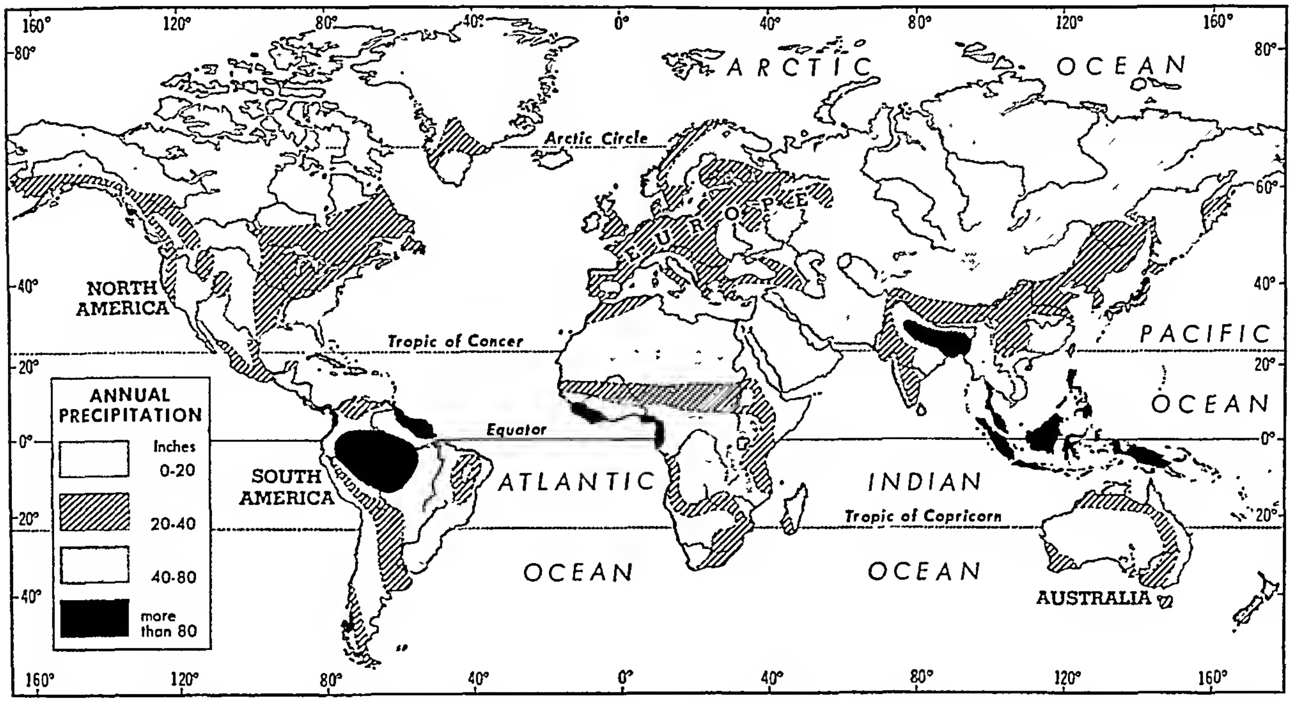
Where Does Rain Come from?

The oceans are the chief source of rain, but lakes and other sources of water also contribute to it. The heat of the sun evaporates water into the atmosphere. There it remains as invisible vapor until it is condensed, first into clouds and then into raindrops. This happens when the air is cooled (*see* Clouds; Evaporation; Water).

The formation of rain clouds may be local. During a hot summer day, rising air over a moist region may cause cumulus, or woolpack, clouds to form in cooler air above the surface. These clouds darken to rain clouds as they receive more moisture. Cooling further in the afternoon, the moisture condenses to rain and causes a thundershower (*see* Storms). Such rainstorms occur almost constantly in the doldrums, a hot, calm belt on either side of the equator. Cumulus clouds can sometimes be made to release rain by "seeding" them with dry ice or silver iodide particles. This causes partly condensed vapor to form drops that fall as rain. Commercial rain makers have used these methods, and have claimed success, since 1946.

In contrast to locally generated rainfall, much of the moisture received by many parts of the earth has been brought from distant oceans by the prevailing winds. Most of the rain over southeast Asia (including the Indian peninsula, China, and parts of Manchuria) and northeast Africa is brought by monsoon winds that blow steadily throughout the summer

HOW RAIN FALLS AROUND THE WORLD



The world's rainiest places are largely confined to the equatorial belt. The only extensive region of heavy rainfall outside the tropics is the Ganges-Brahmaputra Valley on the Indian peninsula. Europe and eastern North America are watered by cyclonic storms that develop within the system of prevailing westerly winds. The Arctic regions receive little moisture.

from the Indian and the Pacific oceans (*see* Winds). The moist air is cooled as it blows inward over rising land and lets fall abundant rain. This situation makes Cherrupunji in western Assam, India, one of the two rainiest places in the world. An average of about 450 inches of rain a year falls there.

In the belt of prevailing westerly winds which blow over most of North America and Europe, much of the rainfall is brought by cyclonic storms. These storms may be likened to great whirls of air, hundreds of miles across, which draw in moist air from their eastern and southern edges. Toward the center of the storm, the moist air is forced upward and cooled. This cooling gives rain to every region over which the center of the storm passes (*see* Weather). European Russia, France, Hungary, and Argentina enjoy good rainfall from cyclonic storms.

High mountain ranges or plateaus usually force rain out of any moist winds that strike them, for they deflect the air up to cooler heights. Most of this rain falls on the slopes and mountainsides that face the wind; the other side beyond the crest receives little or no benefit from it. This is true on several of the Hawaiian Islands. Waialeale peak on the island of Kauai, with an average rainfall of 460 inches a year, has the distinction of being the rainiest spot in the world. Yet only a few miles away, on the leeward slope of the mountain, the average fall is only 20 inches. Southwestern Colorado, Tibet, Khorasan, and parts of Bolivia and Peru are dry plateaus on the leeward sides of mountains. If a region does not provide some means of cooling the winds that blow over it, it cannot have any rain. This is the case at certain seasons in the belts of the trade winds and in the horse latitudes. It is true the year round in the Sahara, the deserts of Arabia, and along the coast of South America from 5° to 30° south latitude.

Rain Needed by Various Plants

Different plants require different amounts of moisture. Cotton and corn need a great deal. Hard wheat needs much less, and grows well west of the Missouri River where the moisture is insufficient for corn. Plants with deep taproots, such as alfalfa, or plants with leathery surfaces that check evaporation, such as the cactus, need very little rainfall.

Plants do not necessarily thrive in a region which receives the minimum rainfall they require. This minimum must fall during their growing season, and local conditions must tend to keep the moisture where it falls. Thus, the state of Chihuahua in Mexico receives moisture enough for almost any crop, but most of it comes in the summer and autumn. Evaporation is rapid in the clear, hot air; a hard clay subsoil prevents absorption into the ground; and as a result, Chihuahua is largely a desert. High winds over a region increase the amount of rainfall needed by increasing the loss due to evaporation.

Rainfall Belts in the United States

The United States is divided into five belts of varying value for agriculture. These belts are shown on a map in the article Drought. They are fixed largely by rainfall, although temperature, mountain ranges, and other factors are important.

Most of the moisture in the United States is brought originally by the prevailing winds from the Pacific Ocean, the Gulf of Mexico, and to some extent from the Atlantic Ocean and the Great Lakes. These prevailing winds come from the west, and bring

cyclonic storms; but they are modified somewhat as far north as Ohio and as far west as Texas, Arkansas, and Missouri, by monsoon winds from the Gulf.

The west coasts of Alaska, British Columbia, Washington, Oregon, and northern California receive ample rain, as moisture-laden winds from the Pacific are forced upward by the Coast Ranges and the Sierra Nevada. Southern and Lower California are dry, particularly in summer, because they feel the drying influence of the trade winds. In these latitudes the winds remain dry over Arizona and New Mexico. Over central Texas, cyclonic storms begin to receive moisture from the Gulf of Mexico, and monsoon winds also bring moisture from the Gulf. In the mountainous parts of the West, the winds can obtain some moisture from melting snows and mountain lakes, and precipitate it upon near-by highlands.

East of the Rocky Mountains, the rainfall increases as the cyclonic storms draw in moisture from the Gulf of Mexico, the Great Lakes, and the Atlantic Ocean. The supply of moisture from the Gulf is the most reliable; hence the country north to the Ohio River always has abundant rainfall. Likewise the regions immediately west of the Great Lakes and along the Atlantic never suffer seriously from lack of rain; but an occasional deficiency is found between these two areas, from Iowa to Ohio. Viewed as a whole, the United States can be roughly divided at the 100th meridian into an eastern portion of good rainfall and a western portion of variably good and bad rainfall. This meridian runs approximately down the middle of North and South Dakota, Nebraska, Kansas, Oklahoma, and Texas.

Measuring Rainfall

Rainfall may be measured by catching it in any flat-bottomed vessel with perpendicular sides, placed exactly level where it will receive the full force of the rain. The depth should be gauged with a very thin ruler—a thick one would raise the water level. As it is difficult to measure small amounts accurately, a special rain gauge has been devised, with a funnel and an inner can so proportioned that each inch of water in it stands for one tenth of an inch actual rainfall.

RAISINS. Raisins really are small, extremely sweet grapes, carefully dried in the sun. Only a few regions in the world can produce them, because when the grapes are ripe, the grower must have many weeks of hot, rainless weather in which the grapes can dry.

Regions adjoining the Mediterranean, particularly the Spanish provinces of Malaga, Alicante, and Valencia, parts of Greece, and Asia Minor near Smyrna, have the required climate (*see* Climate); so do parts of southern Australia. The San Joaquin and Sacramento valleys of California are ideal for raisin culture and lead the world in production. The drying season, from August to November, is hot and rainless, while the near-by mountains provide water for irrigation during the growing season.

In California, the grapes ripen in August. They are cut from the vines and allowed to lie in trays between the rows for from 2 to 3 weeks. A further period of drying in boxes follows. Then they are taken to the packing plant, where endless-belt conveyors carry them through the processes which prepare them for market. Special machinery removes stems and dirt; the grapes then are washed, steamed or soaked in special solutions, dried, inspected, and packed. About three fourths of the original weight of the grapes is lost in drying.

The largest raisins are produced from Malaga or Muscatel grapes. Seedless raisins are made from the Sultana grape, grown near Smyrna and in Greece and California, and from the Sultanina, or Thompson Seedless, of California (*See also* Currants; Grapes.)

MANY-SIDED RALEIGH *and His* VISIONS

RALEIGH (*ra̤'lē̆*), SIR WALTER (1552–1618). Politician, soldier, sailor, explorer, poet, and historian, this popular hero stands out as an illustrious example of the many-sided genius of the men of Queen Elizabeth I's time and of the stirring and adventurous life of the day. But his greatest title to fame rests on his efforts to colonize the New World. Even in an age that abounded in keen intellects and bold imaginations, Raleigh shone because of his brilliant mind and daring imagination. To him came the vision of a new England beyond the seas, and the irresistible appeal of this dream clung to him all his life. Through many years of failure and disappointment he strove to fulfill this vision.

Born at Hayes, Devonshire, in 1552, Raleigh entered Oriel College, Oxford, in 1568, but left the next year to fight on the side of the Huguenots in France. In 1580 he distinguished himself in the suppression of the Irish rebellion in Cork and soon afterward was introduced at court and became a favorite of Queen Elizabeth I. You remember the story of how he won the Queen's favor by throwing his costly velvet cloak on a muddy spot to enable her to walk over it dry-shod.

Raleigh's tall and handsome figure, his dark hair, lofty forehead, resolute bearing, courtly manners, and spirited wit combined to form an imposing personality; and all the advantages that nature had given him were heightened by a gorgeous splendor in dress and jewels. But he was proud, haughty, and impatient, and so made hosts of enemies and was never fully admitted to the Queen's counsels in matters of state. The playful name of "Water" which she applied to him would indicate that she recognized the instability of character which was his great fault and which in the end worked his ruin. Elizabeth, however, lavished numerous favors upon him throughout her reign, and he discharged with conspicuous ability the responsibilities of several important positions to which she appointed him.

THE BOYHOOD OF SIR WALTER RALEIGH

Raleigh grew up on the south coast of Devonshire. This picture by Sir John Millais, painted in 1870, shows him sitting on the seashore with a friend and listening with rapt attention to a sailor who is narrating his adventures.

Before his appearance at court, Raleigh had gone with his half brother, Sir Humphrey Gilbert, on voyages of discovery. Up to that time, Englishmen had made no permanent settlements in America. Raleigh's position at court gave him opportunity to push his great project, although the queen would not let him lead any of his colonizing expeditions in person.

Raleigh was tireless in his efforts to settle "our people in America" and sent out expedition after expedition. The name Virginia (in honor of the "virgin queen," as Elizabeth was called) was given to the area explored by one of his expeditions (1584). Three settlements were made on islands off North Carolina, but none survived. (For the story of the "lost colony" of Roanoke, *see* North Carolina.) Raleigh's pioneer work paved the way for later settlements. His men brought back tobacco and potatoes. Raleigh popularized smoking and created a demand for the tobacco leaf, which was to become a profitable crop in the colonies.

Raleigh was in Ireland (where he had introduced the potato) when the Spanish Armada appeared in English waters (1588). As vice-admiral of Devon he may have had a part in that exciting naval battle (*see* Armada, Spanish). Later he took part in expeditions against the Spaniards. In 1595 he sailed at the head of an exploring expedition to Guiana, on the north coast of South America, in search of the fabled El Dorado (gilded man), the supposed ruler of a region abounding in gold and jewels. He sailed up the Orinoco, but returned empty-handed after much hardship. He recounted his adventures in a book published in 1596, 'The Discovery of the Empire of Guiana'. In the same year he took part in an expedition against Cadiz, Spain.

Raleigh's popularity at court had been waning since his marriage to one of Elizabeth's maids of honor, Elizabeth Throgmorton. When Elizabeth I died and James I came to the throne, complete disaster overtook him. The Scottish king suspected that Raleigh had worked against his becoming king of England; so he deprived him of his numerous offices and privileges.

In July 1603 Raleigh was arrested and sent to the Tower of London. His trial was conducted with gross unfairness, and he was condemned to death for conspiring against the king's life. His gallant bearing, however, turned public opinion in his favor, and the death sentence was not carried out.

He spent the next 13 years a prisoner in the Tower. Most of the time his wife and son were permitted to

live with him and he was visited by many great scholars and poets. During this period he worked on a 'History of the World' for King James's son, Prince Henry, whose favor he enjoyed. One volume of this vast project was finished, carrying the narrative only to 130 B.C. Raleigh also wrote on political philosophy and produced verses of good quality.

Raleigh persuaded King James to release him in 1616 so that he might lead an expedition to the Orinoco River and bring back some of the gold from a mine he claimed to have discovered. Disobeying the king's command, his men fought the Spaniards. Raleigh returned empty-handed to face the enraged protests of Spain.

King James, who wanted to keep on good terms with Spain, rearrested Raleigh, and he was executed in 1618 under his old sentence, which had never been revoked. Cheerful and resolute to the last, he asked to see the ax when he was led to the scaffold. Touching the edge, he said, "This is a sharp medicine, but it is a sure cure for all diseases." Thus died the man who gave the first great impulse to the English colonization that produced the United States and Canada.

RALEIGH, N. C. When the Raleigh site was selected as the state capital in 1788 it was a wooded area that contained only a courthouse, a jail, a tavern, a log church, and one house. The townsite was plotted in 1792 and named for Sir Walter Raleigh. Today the city is a center of education, textile manufactures, tobacco sales, and general trade for central and eastern North Carolina.

Raleigh stands at the juncture of the Piedmont Plateau and the Coastal Plain near the geographical center of the state. Its comfortable, unpretentious houses are surrounded by large lawns and gardens shaded by tall trees. Six-acre Capitol Square lies at the city's center. The first Capitol, a brick building, was erected there in 1794. The present Capitol, an impressive but simple granite structure, was completed in 1840. Other state buildings, including the red brick and sandstone Governor's Mansion, enclose the square. The Joel Lane House, built before 1771, is the city's oldest building. State institutions at Raleigh include a school for the blind, a penitentiary, and a hospital for the insane.

In or near Raleigh are six colleges. The largest is the State College of Agriculture and Engineering. Its experimental farms lie outside the city. On the campus is the cottage in which Andrew Johnson, 17th president of the United States, was born. The campus also has a nuclear reactor authorized by the Atomic Energy Commission. The college was founded in 1889 and made a unit of the University of North Carolina in 1931. Peace College, St. Mary's School and Junior College, and Meredith College are schools for women. Raleigh has two Negro schools —St. Augustine's College and Shaw University.

Raleigh's first railroad train, from Gaston, arrived in 1840. Raleigh has the city-manager form of government. (*See also* North Carolina.) Population (1950 census), 65,679.

RAPHAEL (*răf'ā-ĕl*) (1483-1520). One of the great painters of the Renaissance was Raphael, born Raffaello Sanzio, or Santi. His Madonnas are more beloved than those of any other artist.

Raphael was born in the ducal city of Urbino in Umbria, a district in central Italy. His father, Giovanni Santi, or Sanzio, was a minor painter and poet. He died when Raphael was 11, and a few years later the boy went to nearby Perugia to serve as an apprentice to his father's friend Perugino. He quickly learned Perugino's style of realistic religious painting, and gradually he became a greater painter than his teacher.

From 1504 to 1508 Raphael spent most of his time in Florence. In this great cultural center he met Michelangelo, Leonardo da Vinci, and Fra Bartolommeo. He studied and copied the works of these and other artists and quickly absorbed the new Florentine style. His original works were chiefly Madonnas (*see* Madonna). Raphael's Madonnas are gentle and extremely beautiful, more ideal than realistic. They have oval faces, with refined regular features, and their figures are well proportioned, supple, and graceful. Among the most famous are 'Virgin with a Lamb', 'Madonna of the Goldfinch', 'Madonna of the Chair', 'La Belle Jardinière', the 'Sistine Madonna', and the 'Madonna and Child Enthroned'. (For picture in color of this last, *see* Painting.) During his lifetime, Raphael painted more than 300 pictures on the Madonna theme.

In 1508 Pope Julius II decided to have certain rooms in the Vatican redecorated. When he saw Raphael's sketches, he commissioned him to redecorate with frescoes the walls of four rooms, or *stanze*, in the pope's private apartments. In these murals Raphael showed his genius for grouping harmoniously crowds of magnificent figures. He is at his best in the 'School of Athens' and the 'Disputa', or 'Triumph of Faith'.

Julius II died in 1513. His successor, Leo X, appointed Raphael chief architect for the rebuilding of St. Peter's after the death of Bramante. He also commissioned Raphael to make full-scale cartoons for ten tapestries that were later woven in Brussels for the Sistine Chapel. In his later years, Raphael painted portraits. The best known are 'Pope Julius II' and 'Baldassare Castiglione'.

Raphael's personal beauty, kindliness, and courtly manners made him generally beloved. Living in the pope's private apartments, he never lacked for money and lived like a prince. At times he had 50 assistant painters and craftsmen working from his designs. His assistants regarded him with awe; but Raphael always thought of himself as a pupil and continued to learn from other skilled artists how to bring his own works nearer perfection. With Michelangelo and Leonardo da

THE WORLD-FAMOUS 'MADONNA OF THE CHAIR'

Raphael's masterpiece known as the 'Madonna della Sedia' or 'Madonna of the Chair,' from the low chair upon which the virgin is seated, hangs in the Pitti Gallery in Florence. The picture owes its origin to a curious incident. It is told that for years Raphael had been searching for the proper model for a Madonna, but did not find her. One day, passing along the street, he encountered an Italian peasant woman seated in a doorway holding a boy in her lap while another stood by. She was dressed in the picturesque colorful costume of the Roman people and was exactly the type he had been seeking. Raphael had a pencil but no paper so he seized the cover of a wine cask lying on the ground and made his sketch upon its smooth surface. From his sketch he worked out in rich oils what has been called since "the most popular painting ever made." Notice how the curved lines of the figure, the soft folds and design of the draperies, and the round chair back follow the circular outline of the painting.

Vinci, he is regarded as one of the three great painters in whom the Italian Renaissance flowered. He died, at the age of 37, before he could complete his famous picture 'The Transfiguration'.

To appreciate Raphael's work fully one must visit Rome; but many galleries elsewhere in Europe contain examples of his art, and a few of his paintings are in the United States. The Metropolitan Museum of New York City owns an early Madonna. The beautiful 'Madonna of the House of Alba' and 'St. George and the Dragon', which Andrew Mellon bought from the Hermitage Gallery in Leningrad, are in the National Gallery of Art at Washington, D. C.

RASPBERRY. The raspberries in the gardens of today are the cultivated descendants of the wild briar patch or "bramble tangle." A great many different varieties have been developed and improved from both European and American wild species.

The "black cap" or black raspberry is a native of America, as is also the most widely distributed variety of red raspberry. The European red, which has been cultivated for several centuries in England and was one of the earliest fruits introduced into the United States, furnishes a superior berry but is adapted to the home garden rather than to commercial fruit growing. It is not so hardy as the American red, and instead of ripening for one marketable crop the berries ripen a few at a time, supplying the home table over a longer period.

The large loganberry is believed to be a hybrid between a wild blackberry of California and a red raspberry (*see* Loganberry). Burbank crossed the native dewberry, a fine flavored blackberry, with a red raspberry and produced a berry superior even to the loganberry, which has been given the name "Phenomenal." Another of his successes is the "Primus," a hybrid of a blackberry and a raspberry which bears fruit almost as large around as a penny, especially sweet and fine flavored.

The raspberry is distinguished from the blackberry by the fact that the ripe fruit comes off the stem like a small cap or thimble. The raspberries are propagated by root cuttings and by "layering," which means covering the branches with soil to induce them to take root. The blackcap raspberry forms new plants from the tips of the branches that bend over until they touch the ground and take root. Most of the garden varieties have plain white flowers, but some of the wild raspberries are very ornamental in cultivation.

RAT. The story of the brown rat is an endless tale of piracy. Through the centuries this animal has preyed on man. It is the invader and attacker, while man defends himself as best he can. Besides living at man's expense, the brown rat is a carrier of disease. The fleas that live in its fur are capable of spreading bubonic plague—the black death. In this way it has been responsible for the death of more human beings than all the wars of history (*see* Black Death).

THE COMMON RAT, SCOURGE OF MANKIND

Shrewd, watchful, and seldom seen by day, millions of brown rats like this one manage to live well at man's expense. Notice the hand-like paws with which he can swim, burrow, scale walls, and even carry off hens' eggs without breaking them. His life span is only three to five years, but during that time he does an enormous amount of damage.

The brown rat (also called the common house rat or Norwegian rat) weighs about three-quarters of a pound. Individuals vary in color from almost pure gray to reddish- or even black-brown, depending on their environment. The total length is 16 to 19 inches, the naked tail being 7 to $7\frac{1}{2}$ inches long. It dominates all other kinds of rats, driving them out or killing them off. Wherever man lives (except in the far North and in very dry lands) there also lives the rat, competing with him for the good things of the earth, and committing wanton destruction in its fight for food and shelter. In the United States alone, the property and crops it destroys each year are valued at more than 200 million dollars.

Originally a native of Asia, the brown rat migrated into Europe at about the time of the Crusades, partly by land and partly aboard the ships of the returning Crusaders. Sweeping the continent, it virtually killed off the comparatively harmless native black rat. Its numbers increased in direct proportion to the wealth and prosperity of the people of Europe.

During the American Revolution, the brown rat invaded the United States. At first it infested only

the seaports. Soon great migrations took place. As the pioneers moved westward the rat followed them to claim a share of the fruits of their toil.

The Secret of the Rat's Success

Brown rats have extraordinary powers of adaptation. Wherever men have plenty, the rats grow fat and multiply. They breed from six to ten times each year, and each litter contains from six to ten blind and hairless young. The new-born females will themselves have litters within three or four months. If unmolested for three years, the descendants of a single pair of rats would number more than 350 million.

When hard times come the rats have a solution. Lacking other foods, they begin to eat one another. In this cannibal contest only the strongest survive, ready to produce more vigorous generations. This may account for the increasing difficulty in outwitting present-day rats. If famine in a certain area continues, they depart to prey on men elsewhere. When prolonged droughts assailed Kansas in the 1930's, hordes of rats left on every outgoing freight train.

The same trick seldom fools rats twice. A poison mixed with food may kill rats the first time it is used. Then the rats in that area avoid that poison for a long time. Older rats sniff or sample poisoned bait and warn the others.

Red squill is a rat poison that does not hurt farm animals. They simply throw it up. But rats cannot vomit, and therefore they die. Another poison called *antu* (alpha-naphthyl thiourea) is a gray powder with little odor or taste. It is harmless to man and to most animals, including black rats; but it causes dropsy of the lungs in brown rats. An effective poison is sodium fluoroacetate. It is almost odorless and rats do not detect it in food or water. It is poisonous to man. Only licensed exterminators can buy it.

The professional exterminator may also fumigate with poison gas; or he may use the blocking method—covering all holes into a house except one. When the rats are inside, an obstruction falls over this hole. Then men enter and kill the rats with clubs, often with the aid of dogs. Many trained dogs are good ratters. Most cats are worthless as rat catchers.

WARDING OFF RATS

Rats carry disease. To keep them from boarding ships or coming ashore from infected vessels, disks like the one shown are placed around the mooring cables.

Rats are skillful at frustrating traps. Observers have watched adult rats teaching young rats the art. The big rat knocks the trap against a wall to spring it, then leisurely eats the bait; or it inspects the trap from a distance, then ignores it. Rats are wary of "blind alleys." The electronic rat trap foils this instinct. This trap looks like a tunnel open at both ends. A photoelectric device closes entrance and exit after the rat has entered. Another device electrocutes it.

Other Members of the Rat Tribe

The smaller black rat has also been introduced from Europe into North America, but has always been quite rare. The wood, trade, or pack, rat is noted principally for its amusing pranks. It is found in the southern part of the United States and on the Pacific coast from British Columbia to Central America. The cotton rat, found in the cotton belt, is a vicious and destructive animal.

The coypu rat of the West Indies and Central and South America is the largest of all rats, attaining 20 inches in length and a weight of 8 pounds. The Syrian golden hamster is used in medical research laboratories (*see* Hamster). There are many species of hamsters from Europe, Asia, and South America. The kangaroo rat, found in the southwestern United States, is a harmless creature. It has short forelegs, long hindlegs, a long tail ending in a tuft, and it jumps like a kangaroo. It possesses cheek pouches for collecting food. A similar animal, found in the sandy plains and deserts of Asia, eastern Europe, and northern Africa, is the jerboa. It is remarkable for the long leaps it uses in escaping its foes. (*See also* Mouse).

The name rat is applied in the stricter sense to large rodents of the mouse family (*Muridae*) and especially to members of the genus *Rattus*, such as the black rat (*Rattus rattus*) and the brown rat (*Rattus norvegicus*). In a wider sense it is applied to certain rodents which are not *Muridae*, such as the muskrat, the kangaroo rat, and the coypu rat.

RATIO. In mathematics, ratio is the relation between two numbers or two quantities of the same kind. It may be expressed as 1 to 2, 1:2, or 1/2. If I have one apple and my friend has two, the ratio of mine to his is 1 to 2, 1:2, or 1/2. If two ratios are equal, they form a *proportion*. Such a proportion might be $3:5 = 6:10$, or $3/5 = 6/10$.

The important aspect of ratio is not the numbers or quantities themselves, but their relationship. The ratio of 1 to 2 is the same as the ratio of 5:10 or 2000/4000. Ratios may also be reversed. For example, the amount spent for food as compared to the amount spent for rent is 3 to 1; by reversing, the ratio of rent to food is 1 to 3.

Ratios are actually problems in division. In the ratio of 2000/4000, each figure divided equally to its lowest relative number is equal to 1/2. Ratios that will not yield exact relative reductions can be stated in close approximations—3 1/2 to 5 or 7 to 1 1/4. Proportions containing one unknown quantity, such as $x/4 = 7/14$, are solved by cross-multiplication. (*See also* Arithmetic.)

RATTLESNAKE. North American rattlesnakes are gentlemen by comparison with other rattlesnakes. Usually they do not strike unless disturbed. The series of rattles on the tail gives the snake its name.

These rattles are formed of hard, horny cup-shaped rings, fitting loosely into one another. When the

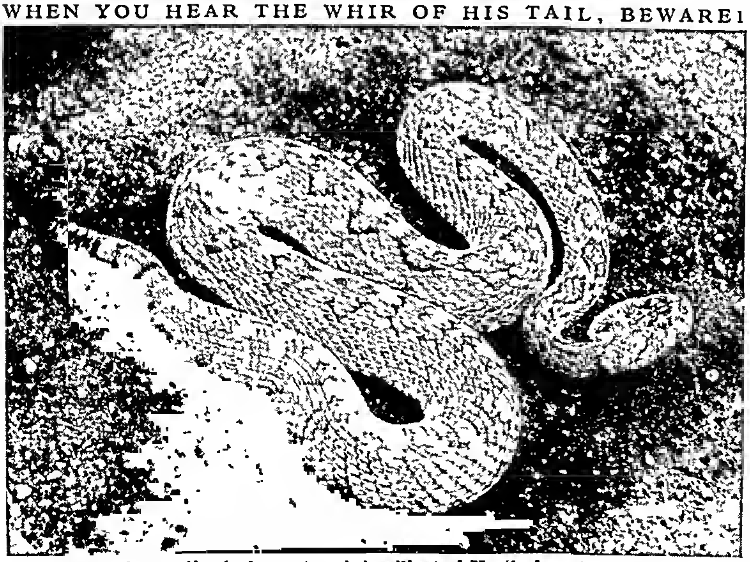
snake is excited, its sensitive tail vibrates; and the rings, striking together, make a dry, sharp whirring noise that may be heard as far as 20 yards away.

Young snakes have only a blunt tip at the end of the tail formed by a knoblike growth of bone that is covered with thick skin. When the snake molts, or sheds its skin, this horny tip is retained and forms the first ring of the rattle. A new ring is added each time the skin is shed, and, as the snake grows larger, each ring is correspondingly larger and so causes the rattle to conform to the tapering shape of the snake. The belief that a rattlesnake's age can be told by the number of rattles it has is not true. It adds from two to four rings a year, usually three. The addition occurs when the skin is shed. The rattle seldom numbers more than ten rings. Vibrations of the tail are so great that the rings near the tip soon wear down or break off.

How the Poison Fangs Work

A rattlesnake does not have to be in a coiled position to strike—in fact, it cannot strike in this position. It strikes by throwing its neck into an S-shaped loop and then straightening out the S. The strike is about two thirds the length of the snake's body. When the blow finally falls it comes with lightninglike speed. The fangs, in the upper jaw, curve out and back from the open mouth. They are perforated like syringes. As they sink in, the pressure on the poison sacs at the base of the fangs squirts the venom into the wound. The venom attacks the nervous system. It also destroys the walls of blood vessels permitting the escape of red and white blood cells. (For emergency treatment, *see* Snakes.)

WHEN YOU HEAR THE WHIR OF HIS TAIL, BEWARE!



This is the diamondback, largest and deadliest of North American rattlesnakes. He is named for those markings on his skin. Notice the large swellings at the back of his head, which contain the poison glands.

There are about 16 species of rattlesnakes, all of them in the New World. They belong to the family of pit vipers, the *Crotalidae* (*see* Vipers). The habits of the species are similar. They are rather sluggish, and will slink away unless molested. All species feed on rats, mice, and other small rodents. The young are born alive in late summer, and have the full poison equipment at birth. As cold weather approaches, the snakes congregate in hollow logs, in caves, or under rocks and, winding themselves into a mass, sleep till spring.

TWO NEEDLES OF DEATH

Rattlesnakes don't bite. They jab. Those fangs are built like hypodermic needles, and inject poison from glands situated at the jaw angle. When the mouth is closed, the fangs fold back against the palate.

The worst enemy of the rattler, aside from man, is the hog. It roots the snakes out and makes a meal of them, apparently with no bad results from the bites it receives. This is because the pig's tough skin and the layer of fat under it do not allow the poison to enter the blood. The king snake, the black snake, and certain birds of prey also eat the rattler.

The Most Common Rattlers

The common or banded rattlesnake, found in the eastern United States, is of a bright tawny color marked with dark brown, and varies in length from 3 to 5 feet. It inhabits rocky and wooded places. The diamondback of the Southern states grows to a length of 8 feet and is often 15 inches around. This species lives in swampy places and swims well. Its yellowish body has plainly outlined diamond-shaped black blotches. The plains or prairie rattlesnake is a smaller, lighter colored snake with less distinct markings, which grows to about 30 inches. It often makes its home in the burrows of the prairie dog, where it ungraciously feeds on the young of its host. Other species are found in various districts of North and of Central America, and in parts of South America. Among the most curious is the "horned rattler" of the southwestern United States, which has hornlike cones above the eyes. It is also called the "sidewinder" because it wriggles sideways over the ground. The pigmy rattler of the southeastern states grows only about 20 inches long. It has a gray body with jet-black saddles.

Most rattlers belong to the genus *Crotalus;* but the pigmy or ground rattlers are set apart in a separate genus, *Sistrurus.* Scientific name of common rattlesnake, *Crotalus horridus;* diamondback, *C. adamanteus;* plains, *C. confluentus;* horned, *C. cerastes;* pigmy, *Sistrurus miliarius.*

RAVEN. The raven has a considerable historical background, for it was the first bird sent from Noah's ark, and it was the bird which fed the prophet Elijah. The raven was also the messenger of the Norse god, Odin, and its figure was on the flag that the early Northmen (Danes) carried into England. Some of the Pacific coast Indians place its image on their totem poles. It is widely mentioned in literature. Edgar Allan Poe in his poem 'The Raven', with its repeated refrain of "nevermore," has labeled this bird as the symbol of despair. Its dull, black plumage and its croaking voice help account for its dismal reputation.

Ravens are as long-lived as man. Pairs mate for life and year after year use the same nest. They feed on small rodents, dead and decaying flesh, and insects. Like the crow, the bird can be taught to imitate sounds and speak a few words.

THE BIRD OF MOURNING

Poe's famous poem has given the raven a reputation as a melancholy bird, but really he is impudent, inquisitive, and mischievous.

With crows, jays, and magpies, ravens make up the family *Corvidae*. They are found in almost the whole of Europe, in Africa, and in northern Asia. There are three species in North America. The northern raven (*Corvus corax principalis*) is found in Alaska, Canada, northern United States, and in the higher Allegheny Mountains south to Georgia. The American raven (*Corvus corax sinatus*) and the white-necked raven (*Corvus cryptoleucus*) are western birds.

RAVENNA, ITALY. This picturesque old city, lying in a marshy plain near the Adriatic Sea, 75 miles south of Venice, is interesting today chiefly for three reasons. The military expert remembers it as the scene of the great battle of Ravenna in 1512, in the Italian wars between France and Spain, and as the headquarters of a flotilla of American submarine chasers in the Adriatic in 1917–18 in the first World War. The lover of literature sees Ravenna as the city where the poet Dante died and is buried. The artist and architect attach importance to the city because nowhere else are there so many striking examples of early Christian and Byzantine architecture and mosaics.

In the days of Emperor Augustus, Ravenna was a great Roman naval station with a harbor capable of sheltering 250 ships, but today it is separated from the sea by six miles of marshy ground, traversed by an unimportant canal. The industries are few, consisting mainly of wine making, breeding silkworms, and manufacturing lace.

The city presents a somewhat somber appearance, as if mourning for its glorious past. The most venerable of the churches is the cathedral of Sant' Orso, which dates back to Roman times, but which has been almost entirely rebuilt. There are 12 other churches or "basilicas" in Ravenna originally built between the 5th and 8th centuries, constituting a priceless architectural heritage of early Christianity. Another interesting historical monument is the two-storied tomb of the great Ostrogothic king, Theodoric, dating from about 520.

The battle of Ravenna in 1512, in which the famous French leader Gaston de Foix was killed while defeating the superior forces of the Spanish and papal armies, is interesting because of the employment of artillery mounted upon carts. This battle was a forerunner of modern warfare, in which trained and specialized troops replaced the haphazard armies of feudal days.

Ravenna was taken by Theodoric the Ostrogoth in 492, after a three years' siege. For 200 years thereafter the city was the capital of the exarchate of Ravenna, the last stronghold of the eastern emperors of Constantinople in Italy. It was taken soon after by Pepin, king of the Franks, who bestowed the entire exarchate upon the pope. In the later Middle Ages, however, Ravenna was ruled by tyrants of the Polenta family. When the lagoons on which it was built began to fill up, separating the city from the sea, it lost importance. In 1860 it became part of Italy. In the second World War Ravenna was captured by the Allies with little damage to the city. Population (1951 census, preliminary), 92,431, including suburbs.

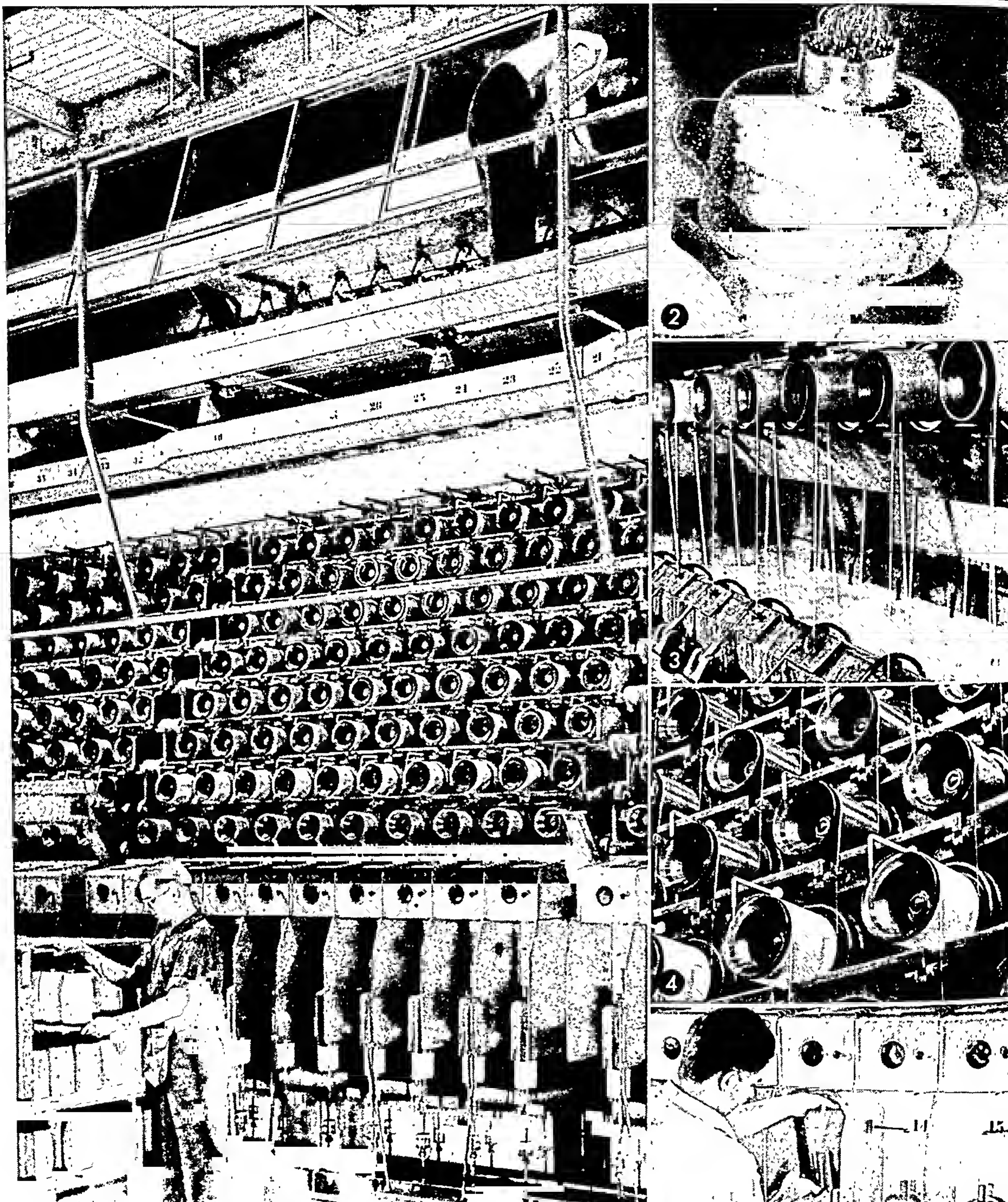
VERSATILE RAYON—*A Major* TEXTILE FIBER

RAYON. The silkworm gave man his first idea of making rayon. "Silk is only liquid gum," said Réaumur, the French naturalist, in 1734. "Could not we ourselves make silks with gums and resins?" Many tried to do this, but 150 years passed before Count Hilaire de Chardonnet, a French scientist, was successful.

While helping the great Pasteur in the study of the silkworm Chardonnet noticed how the busy little spinners digested mulberry leaves into liquid and then forced it out through two tiny holes (spinnerets) to form slender threads (*see* Silk). Unable to match the digestive chemistry of the silkworm, Chardonnet dissolved mulberry leaves with nitric acid. Then he imitated the silkworm by forcing the mixture through tiny holes. Next he tried to avoid using mulberry leaves. He knew that these leaves consisted largely of cellulose, a substance which provides three-fourths of the solid matter in plants (*see* Cellulose). He experimented and got as good results with cellulose from tree trunks as he had with mulberry leaves. His success led him in 1889 to set up a factory at Besançon.

Chardonnet called his lustrous braids and trimmings "artificial silk." He had not, however, succeeded

SPINNING RAYON ON THE CONTINUOUS-PROCESS MACHINE



Here (1) a machine 19 feet high is making rayon from viscose in one continuous process. On the top level of the machine viscose is squeezed through tiny openings in platinum spinnerets (2) into an acid bath. It emerges from the spinnerets as thin threads or filaments. These are solidified by the acid. Then the filaments go to the middle level of the machine, and pass up and down over sets of reels (3 and 4). The reels draw the filaments through baths where they are washed, desulphurized, bleached, and oiled. Finally (5), the filaments are dried on covered, heated reels. Then they are ready for spinning into yarn.

in changing the nature of cellulose. The new product was still cellulose (a vegetable carbohydrate) and not silk (an animal protein). In time the new fiber came to be accepted on its own merits and the term "artificial silk" was dropped. A new word, *rayon*, was coined in the United States in 1924 for all textile yarns made from cellulose solutions.

Four Ways of Making Rayon

Four processes have been developed for making rayon. Mechanically they are similar in principle. In each, the cellulose is dissolved and the solution is forced through tiny holes (spinnerets) in a plate. It emerges as filaments, and these are hardened and combined into yarns. The processes differ mainly in the chemicals used for making cellulose fluid.

Nitrocellulose process. Chardonnet developed this process. The cellulose is nitrated by a mixture of nitric and sulphuric acids. The resulting nitrocellulose is dissolved in ether and alcohol to yield collodion ("new skin"). After this has been forced through the spinnerets the nitrate is removed. Today more economical methods are used.

Cuprammonium process. The cellulose is immersed in a copper sulphate solution, and the mass is dissolved in a solution of ammonia. An acid bath solidifies the filaments and removes the copper residue. Then the filaments are stretched out on a winding mechanism. This is the least important rayon-producing method in use today.

Viscose process. The cellulose is treated with caustic soda and carbon disulphide. This converts it into a honeylike liquid. The extreme stickiness of the liquid suggested the name *viscose.* The filaments are hardened in a bath containing an acid (usually sulphuric acid) and one or more salts (sodium sulphate, ammonium sulphate, or zinc sulphate). Commercial manufacture of rayon by this process began in England in 1905. Today it is the most widely used process.

A striking invention in the viscose industry was the *continuous process machine.* This single machine performs all the separate steps of washing, desulphurizing, bleaching, oiling, and drying, as the yarn moves from reel to reel. A segment of yarn passes from bath to bobbin in only five and a half minutes.

Cellulose-acetate process. The cellulose is combined with acetic acid to produce white, flakelike particles of cellulose acetate. These are dissolved in acetone and the solution piped to spinnerets. The filaments are emitted into warm air, which evaporates the acetone solvent.

English chemists invented the cellulose process, but chemists in the United States developed it. Today it accounts for only a small percentage of the world's rayon but for about a quarter of the rayon manufactured in the United States. Among terms used to distinguish this type from other rayons are *acetate rayon* and *estron. Celanese* and *acele* are trade names.

Two Kinds of Yarn—Rayon and Spun Rayon

Rayon comes from the spinnerets in endless filaments. Their size depends upon the size of the spinneret openings. From large holes comes artificial horsehair; from the smallest, fibers finer than the silk spun by silkworms.

To make *rayon yarn* all the filaments from one nozzle—from a dozen to several hundred—are twisted together, a few turns to the inch. This produces a continuous filament yarn, ready for the weaving or knitting machine. Fabrics made of it can be lustrous or dull, smooth or pebbly, according to the spinning and weaving processes used.

Spun rayon was developed to imitate the rougher textures of wool, cotton, linen, and spun silk. For this yarn, the filaments from all the spinnerets on a frame are drawn together without twist into a rope called a "tow." A cutter then chops the tow into even lengths, from one to seven inches. This chopped fiber is called *rayon staple.* It is not made up into yarn in the rayon factory but is shipped out in bales to be spun on cotton, silk, or wool-spinning machinery.

The short lengths and protruding ends of the staple fiber give spun rayon yarn bulk and fluffiness. For mixing with wool, it is sometimes crimped. In suitable lengths and sizes it blends with all natural fibers. It is also used alone in fabrics that have all the appearance of wool, cotton, linen, or silk.

Sources of Cellulose for Rayon

The main source of cellulose for rayon is wood pulp treated with limestone, sulphur, and bleaches and known as "dissolving pulp." Manufacturers of dissolving pulp use about 75 per cent of western hemlock and about 25 per cent of southern pines, including loblolly, longleaf, and slash pines. Chemists are constantly testing other types of hard and soft woods to find suitable ones. Pulpwood manufacturers deliver dissolving pulp to rayon mills in sheet form.

Cotton linters provide a second source of cellulose for rayon. These are the short, olive-colored, fuzzy fibers left on the seeds after the cotton has been removed. Cottonseed-oil mills delint the fibers and deliver them in bales to plants which convert them into cellulose, or "chemical cotton." At these plants the fibers are "cooked" in an alkaline solution and detergent, then bleached and dried.

"Made to Order" for Particular Purposes

Rayon yarn is "made to order" in several degrees of luster, from shiny to chalky dull. It appears alone or in combination with other fibers in practically all fabrics, from the filmiest chiffons and laces to tough tire cord. It is used in almost all types of dress and suit fabrics; for knitted underwear and hosiery; for carpets; for ribbons, neckties, braids, and shoelaces; for the elastic webbing of suspenders, garters, and girdles, and for embroidery and sewing thread. (For other products made with the same solutions as rayon, *see* Cellulose; Plastics.)

Rayon making was a small industry at the beginning of the 20th century. Today, however, rayon is second only to cotton among textile fibers in the amount produced and consumed in the United States. This country leads the world in production, with the United Kingdom second.

GETTING READY *for* READING

The child who is interested in pictures and curious about printed words is eager to learn to read. So reading readiness develops at home in the preschool years.

READING. No sooner is an infant born than we look for signs of his growing up. The first tooth, the first word, and the first step are exciting evidences of growth. And just as surely as we expect a normal youngster to learn to talk and to walk, so we expect him later on to learn to read. A child's satisfactions at home and in school and his status among children of his age group may be affected by his ability to read. His feelings of self-adequacy and independence are increased by the realization of his competence as a reader. If he can read about the world in which he lives, his life becomes more interesting, for his horizons then stretch far beyond his neighborhood and school. Later as an adult his life will be more satisfying if he enjoys reading.

Reading Begins in the Family

Before we knew as much about the importance of the first years of life as we do today, learning to read was assumed to begin when the child entered the first grade. Once parents had sent a child of normal intelligence and good health to school, they felt that teaching him to read was entirely the teacher's job. Later they might hear the child's lessons and see that he finished his home study, but his success or failure in reading was the responsibility of the school.

From studies of the development of children we have come to understand how a child's personality and his attitude toward himself and others is markedly shaped in the preschool years. Because these early influences have a strong effect in later years, parents of today feel their responsibilities keenly. A child well guided in those years before kindergarten develops more surely into a wholesome, eager youngster able to wrestle with the problems he meets. One of the greatest of these problems is the complicated task of learning to read.

Perhaps this point can be illustrated through a comparison of two four-year-old boys who live in the same neighborhood. Tommy has his normal four-year-old play life with his pals. He also has his part in the life of the family. He sees his father prepare to paint the garage. He watches intently while the paint is mixed and the ladder adjusted. At his father's request he hands him a wire brush for scraping off the loose paint, or he runs to the house to get a hammer. In this as well as in other experiences Tommy is treated by members of his family as a co-worker who is entirely competent to handle certain situations.

Across the street lives four-year-old Philip—quiet, shy, and cautious. His play is carefully supervised by his mother and his needs are promptly met. But so far he has not known the fun of helping his father or mother at work. Although Philip has a good vocabulary and speaks plainly, he seems much younger than Tommy and is not nearly so competent in managing his own affairs.

The personal differences between these two children are largely due to attitudes in their respective home environments. And these differences have a direct bearing on the ability of these children to learn to read.

A youngster who is encouraged to explore new ventures, to grow in looking after his own affairs independently, to accept minor defeats, and to play and work happily with children of his own age becomes a fit candidate for successful adventures in reading. The child who has had unhappy early experiences and unwise guidance may be too shy and too fearful to make those first efforts which are essential if the difficult task of reading is to be mastered.

Differences within a Family

Sometimes children with the same family background differ from one another. Eddie, a sturdy,

plodding seven-year-old was reminded by his teacher, "You don't hurry about your work like your sister Kathleen does." To which Eddie politely answered, "I know—I am Eddie." True. Each child establishes his personality during his first years. And he has a right to insist that we respect him as a unique person—not a copy of a brother, a cousin, or even a parent.

The physical make-up and general health of children contribute to intrafamily variations. Ellen, tall and well built, well coördinated, and full of energy, learns to read almost unaided by the end of her first year in kindergarten. John, her slight seven-year-old brother, is subject to colds and reacts unhappily to reading. The family doctor advises John's mother to be patient and encouraging as they work together to help John build more physical vigor.

Some reading difficulties may be due to defects in vision or hearing. In such cases not only the help of the right medical specialist is needed, but the wisest parental understanding of the problem.

Through patience and an occasional helpful conference with a teacher or other specialist who knows the children, worries are eased and conflicts reconciled so that a wholesome family relationship is developed that is good for children's learning and living.

LEARNING THROUGH DOING

Before the garden was planted, these children learned to recognize the names of the vegetables printed on the packages of seeds.

Learning Is a Child's Business

While a child is growing almost perceptibly from day to day he is also acquiring an amazing amount of knowledge. This phase of growth is so subtle that one does not always realize how much real education is taking place. By the time a child is three he understands most of the daily routines of family life—who does what, how things work, and what he may or may not do. At this age or even earlier he may have a vocabulary adequate to report his wants and to relate simple incidents such as "John fell off his bicycle" or "Daddy went downtown."

The child in a home where reading is an essential part of life may notice family members reading newspapers, books, and magazines. He too may begin some of his reading experiences by looking at pictures in books and magazines. He may have a repertoire of stories which have been read or told to him. He may also have his own books and a preference for some above others. Even before he has mastered the techniques he may have developed some attitudes of like or dislike toward reading.

First Reading Experiences

Formerly, children's first experiences with reading materials were lightly regarded. Their looking at pictures, peering into the book as it was read to them, asking about signs, labels, and letters—all these activities were regarded as pleasant and satisfying to the child but not of any real consequence. Now we realize that from these brief informal contacts with printed materials much learning takes place. Some children actually "teach themselves to read" through them as did Kurt. Kurt was his mother's baking aide. On the instant Mrs. Peterson entered the kitchen to bake, Kurt was there. She would say "Get me the rolling pin," "Get me the cinnamon," and Kurt quickly responded. From being shown which of the spice cans said *cinnamon*, Kurt went on until at five he had mastered the identification of all the labels on the spice shelf.

Mary, who always selected the story which was to be read to her after supper, insisted upon holding the book and turning the pages. It is therefore not surprising that she recognized names and interesting words and phrases from a large number of books before she entered kindergarten.

These youngsters had normal to nimble intelligence, but they also had opportunities to take part in activities that gave them interesting contacts with printed materials. Important in each of these cases was the eagerness with which the child engaged in them. There was no urging or coaxing; there was no subtle pressing. Most children,

if well, need only the freedom to reach out. Given that opportunity, they learn.

Basic Family Relationships

From the foregoing examples which most mothers and fathers can match with similar and even more apt ones, some general and fundamental observations about young children's reading can be drawn. First, certain activities appeal to children. They catch their fancy and kindle their interest. Next, children need the right amount of help to get them started, but they also need to carry on enough of the actual job to feel the thrill of independent accomplishment. With deep satisfaction the child says, "I can do that" or "I know that." This satisfaction is the very fuel that keeps the fire of learning aglow. Adults should try to keep "hands off" and give children their chances to take over even if they make a few mistakes.

There are a few other basic relationships which help in the growth of an emotionally healthy child who in turn can develop into a happy and successful reader. A child needs to feel parental approval and acceptance. He may go off center and need to learn what limits to accept for his behavior. But he must feel that his parents are satisfied with him. He may not be a precocious talker—and perhaps he is luckier if he is not. He may instead be a normal, wholesome, and often plodding child. But only when he feels that his parents wish he were different is he truly handicapped. Then he develops a yearning for acceptance which may make him an unhappy young child who grows into an unhappy adult. If he feels the warmth of parental acceptance of him as he is, he is more likely to enjoy learning. "My mother wouldn't trade me for a red Cadillac—she told me," was the way Billy described his place in the sun. "My mother wouldn't trade me for you," responded Susie. A child's consciousness that he is acceptable to his parents may be the cornerstone of his personality. With a strong feeling that he is quite all right, a child can really "let go" and grow.

Young children do such amazing and fascinating things that it is natural for a parent to exclaim about them. Yet a child's growth ought to be taken in a matter-of-fact way, recognized and commended, but not unduly heralded. "Read about the fire engine," four-year-old Bobby asked his mother. Then going to the bookshelves he got the proper volume and found the right page. Bobby's mother was surprised and pleased. It would have given her much satisfaction later to have told her friends of the incident in Bobby's presence. But she was wise enough not to repeat the story. Children are quick to sense when we are unduly excited about them and in their efforts to get special attention they may miss the real satisfaction of doing things. This is how show-offs are created and how some children lose part of the fun of living and learning. They do need to know that adults note their progress and are pleased, but such recognition should be given casually.

Then there is that on-again-off-again quality of young children's interests. For several days and even for a few weeks a young child may show marked interest in asking about the letters and words which catch his eye. A parent may decide, "Our Patsy is interested in reading." Then suddenly Patsy takes out an old tricycle, hitches a box to it, and appears interested only in dragging about all manner of playthings. She may soon return to her former interest in letters and words—or she may not. From three through five years of age strong interest in reading often emerges, only to be dropped. To expect a young child to sustain an interest or even to return to it may dampen his ardor and even turn him against reading. So it is best to accept a waxing and waning interest as normal child behavior.

A persistent interest in reading is more readily developed between the ages of six and seven. For at this age a child is with other youngsters who are learning to read with day-by-day help from the teacher. Through group experiences at this time, a child is likely to keep up his interest in reading.

Early Experiences with Books

Children are great imitators. A three-year-old wants to use a regular, adult-size knife and fork—"like yours," he says. He also wants to telephone, turn on the lights, and help with the laundry. What he sees adults and other children do he is eager to imitate. That is how he learns. What reading practises is he observing and imitating in these early years? Does he see members of the family reading regularly? Do they look things up in the encyclopedia and dictionary? Do they share and discuss their reading? Do they enjoy hearing something read aloud? From these family experiences a child begins to sense the reasons for reading and to acquire the desire to read.

A child who lives in a family in which reading plays a natural, essential part has a great advantage not only in early childhood but as he approaches the teen age. Within the normal business of daily home life he acquires many of the skills that are essential to his success in reading.

First Year in School

A well-meaning mother without intending to intimidate a child may say: "Wait until you get to school and your teacher will make you listen and remember." A mother who understands that anticipation of going to school and real enjoyment of school life are essential to a child's success will never yield to the temptation to use such a threat in discipline. Teachers like to have each child come to school gladly. They smooth out minor mishaps and disappointments in order to keep the child eager to learn.

The parents' responsibility is to send to school a happy, unworried, unharried child who is regular in attendance. This child may grow slowly and undramatically or by spurts and dashes or with regular unfaltering strides. No matter what his speed, if he is a respected member of a family and enjoys parental understanding and approval, he will be most likely to do his best.

Some children take a year or two to get a grasp of the beginnings of reading. It may be natural for a

parent to grow uneasy and worried over this and doubly so if the more rapid progress of other children is noted. Yet if a child is to be free to work at his best, he must be encouraged, not goaded or worried. More and more schools are making allowances for unevenness in reading development. This is because teachers know that this insures satisfactory progress and a healthy attitude toward school. If a child indicates unhappiness at school, that unhappiness rather than his day-to-day progress in reading should be the matter for first discussion between parent and teacher.

Shall Children Learn the Alphabet?

Parents often ask, "Shall I teach my child his ABC's?" In her little book entitled 'Reading Is Fun', Roma Gans says:

"For children there is something fascinating about arranging items in some kind of series or sequence. A three-or-four-year-old may pick out all the blue beads from a box and place them in a row, next to all the red ones. Later he may string a chain, first a blue bead, then a red, a yellow, a green, and then repeat the sequence. When it comes to the sequence of the alphabet, he seems naturally to gravitate toward this arrangement too. 'What comes after F?' 'What comes after R?' he may question his mother or teacher. Many six-year-old children, without being taught to do so, will sit down and write out the alphabet, persisting until they feel that they have mastered it in its correct sequence.

"Although this learning of letters and their arrangement from A to Z is not a prerequisite for beginning reading, when it has become an interest to children, they should be aided in acquiring success to the degree this interest demands. Children, as a rule, enjoy seeing their names in alphabetical lists. Names are collections of such personal words—no wonder they have special appeal. In many second grades, children keep lists of words in notebooks which they can spell in alphabetical order. At this time, some of them are ready to explore dictionaries and other reference materials solely for the exciting game which this activity presents—for the fun of seeing whether they are able to find a given word."

A Friendly Lift

Methods of teaching reading have changed considerably in the past several decades, and methods are not uniform in all schools. Since it is desirable that the help given a child at home be similar to that given by his teacher, a short conference between the two is helpful when he begins his reading program.

A child who was stirred by the great experience of learning to read brought his primer home so that he might demonstrate his new power. Almost immediately he ran into a word he did not know. "What is this word, Dad?" he asked. "How is it spelled?" asked his father. The child, who was being taught to read by recognizing the general appearance of a word instead of learning it letter by letter, was utterly confused.

Many schools plan group meetings with parents to describe their methods of teaching children to read and to indicate the best way for parents to assist their children. Other schools and many individual teachers send home brief suggestions such as "Your child is now beginning to read alone. When he forgets a word or meets a new word and asks for help, pronounce the word for him. He may not be able to recognize all the letters, so he cannot spell out the word. If he forgets it, tell him again. Your help when he asks for it will be a great aid in his progress."

Through such friendly, easy sharing of his newfound skill at home, a child tends to turn naturally to his home for help in reading and in other school problems.

During school years, the parent serves an important function in aiding a child's comfortable growth in reading. In fact, his home may become even more important than the school in helping him to keep up his interest. Family life has a more personal quality than even our finest classrooms can have. Before school and during school the home is the nurturing influence through which a child learns to enjoy life while growing in competence.

WHERE WORDS AND PICTURES MEET

Some children learn to read by following the words of a favorite story as it is read aloud over and over again.

GROWING *up with* BOOKS

Wherever there are children there should be low book shelves with space for a growing collection of good books. Children like new books, but never tire of old favorites. (Drawings by Elizabeth Orton Jones.)

AS EVERYONE knows it was once a habit of fairy godmothers to attend christenings and to bestow such gifts upon the newly born as beauty, wisdom, and kindness of heart. Since fairy godmothers flourished before the invention of the printing press there is no record anywhere of one who said: "This child shall love to read." Yet, what a gift! A love of reading—a gift worthy of the best of all godmothers!

Reading is still the chief means by which a child learns facts and explores those experiences for which his spirit hungers. Children themselves often realize that there is no substitute for the pleasure of reading. When a group of children was asked to explore the difference between *reading* and such other pastimes as looking at moving pictures and television and listening to the radio, one boy said: "Well, with a book, you can get up in the middle of the night, go get it, and read it again." This was well expressed, for who would not *return* to a pleasure which yields knowledge, strengthens the imagination, awakens mirth, and gives some token of what life may become.

There is, in the minds of some children, such a desire to learn to read that it is like a fever upon them "Whenever are they going to teach me to read?" a small girl asked her father after her first day at kindergarten. And who has not encountered children on busses and subways who asked over and over again, "What does that say, Mother, what does it say?" They ask it of every shop-window sign and every advertising placard.

The child who grows up in a family where books are used, laughed over, and talked about will probably learn to read as easily and as naturally as he learns to eat. Word by word, sentence by sentence, suddenly he is reading, and the kernel of the nut of wisdom is his forever.

The Will to Read

Some children must be persuaded that the pleasure of reading is worth the pain of learning. "Why should I learn to read?" a ten-year-old boy asked. "I look at the pictures and make up my own story." It was not until he was convinced that Robert Louis Steven-

son could "make up" stories more wonderful than any he himself could invent that the boy set himself to the task of learning. For underneath the picture at which he gazed most often, a picture of two lads on their stomachs drinking at a pool, was a sentence which read, "And putting their mouths to the level of a starry pool, they drank their fill." Something of the beauty of the words and the writing caught that boy's imagination. It was a long way from reading in the third grade to this picture from Stevenson's 'Black Arrow', but he leaped over the barriers and read that book for himself by the end of his fourth year in school.

Another small boy who had steadfastly refused to read was given the responsibility for choosing what kind of dog he wanted for his very own. In his zeal to make the wisest choice he read the article on dogs in his encyclopedia and in the light of its information decided on a wire-haired terrier. The terrier proved to be an ideal pet so the boy began to use his encyclopedia to find out about many things, and within a few months he was reading other books too.

Importance of "Wanting to Know"

Interest is the key to learning. If a child is curious about a subject, interested in discovering all he can about it, he will read book after book which may at first seem too difficult for him. If he *wants to know*, he somehow senses the meaning of words, though he may not be able to pronounce or define all of them.

Rudyard Kipling in his great 'Just So Stories' recognized this essential hunger for knowledge in even the youngest children. It was his Elephant's Child, full of "satiable" curiosity who "asked questions about everything that he saw, or heard, or felt, or smelt, or touched." The Elephant's Child with his insistent "I want to know" is the symbol for every child in the world. Indeed he is the symbol for the whole progress of mankind.

Parents who excel even the zeal of fairy godmothers in bringing the great gifts of life to their children can help them to a love of reading by recognizing their changing interests and making sure that the matching information is at hand. One day after a storm a child asks, "What makes it thunder?" If child and parent together seek the answer in a book, the child has his curiosity satisfied. Since it was his question in the first place and it was a book that gave the answer, he begins to depend on reading as a way of finding out.

"Wanting to know" goes beyond a reaching for actual facts. There are also the great unasked, unworded questions which haunt the inner consciousness of children. These have to do with the feelings of hate and love, of envy and pity, of being brave and feeling frightened. Who is wise enough to answer them?

Here is another point at which books are needed. The child who is seeking to understand himself will find a key to the riddle in that great body of writing we call literature. Because literature deals largely with the emotional life of man, a child finds release for his own emotion when he reads. Books help him to identify his own feeling with the feelings shared by everyone. Reading gives him the ability to find pleasure and meaning in simple, common happenings. Even the smallest and most ordinary events—waking, sleeping, dressing, playing—take on an importance beyond himself, because in rhyme or picture book or story all these things have happened to other boys and girls, to children everywhere.

First Introduction to Literature

The spoken word is a child's first introduction to literature: the lullaby, and the rhymes of Mother Goose, with their sure, strong rhythm, their genuine sense of wonder, their music, and their clear word pictures of people and places.

> Deedle, deedle dumpling, my son John,
> He went to bed with his stockings on;
> One shoe off, and one shoe on,
> Deedle, deedle dumpling, my son John.

Is that literature? The very stuff of literature. It is the portrait of a sleepy child, too tired to be undressed properly. And what is the use of it? The use is to say it to a fretful child who cries as he is being undressed. Deep within himself could not that child be saying, "That boy John, he and I are alike," or "I'll not be like that sloppy boy," and the tune of it will go thumping through his head, bringing to a disagreeable task the solace of rhythm.

Early Interest in Pictures

Almost as soon as a child's ear is attuned to the tumbling rhymes of Mother Goose, his eye begins to seek in pictures the shapes of familiar things. His first pleasure is the joy of recognition. Dog! Cat! Man! But no child is content for long with this simple identification. He almost immediately tries to relate one object to another. The dog in the picture becomes "my dog" or "Jack's dog." The child seeks pictures which combine people and animals with such familiar things as chairs and tables in order that he himself can call their names and relate one to another. With this interest in pictures as an incentive, a child is ready to enjoy the many fine picture books which are another approach to literature.

Soon the joy of recognition gives way to a demand for action. The child expects his picture books to answer the questions "What happened?" and "To whom?" and "Where?" At this point the pictures must seem to leap and move across the page.

At about three years of age a child is agape at the world and quick to identify himself with everything he sees: truck, train, boat, fireman, milkman, Indian, cowboy, dog, tiger, or bear. He may be each or all these things in the same day. He has the power to breathe life into inanimate objects by pretending they are real.

Among the stories which appeal to children of this age are those about steam shovels, or tugboats, or trains that behave very much as though they were human. 'Little Toot', the picture story of a brave tugboat in New York Harbor, by Hardie Gramatky; 'The Little House', by Virginia Lee Burton, with its story of a house suffocated by the skyscrapers, which

Fine picture books are carried off to bed and slept with like favorite toys.

is finally restored to the country; and her 'Mike Mulligan and His Steam Shovel'—these are the books to which children return again and again because they have definite plots, because their heroes are endearing and childlike, and because text and pictures are so interwoven that one supplements the other in a happy relationship

First Animal Stories

The animal story interests and excites a child, for animals, like mechanical things, seem to have secret lives of their own which invite the child's power to make believe. 'The Three Bears' and 'The Three Little Pigs' and all the "talking beasts" of simple folklore are creatures with whom a child might well enjoy keeping house.

Beatrix Potter's books about kittens, ducks, and rabbits are really small novels about human behavior, though the world she describes is an animal one. "Now, my dears," said old Mrs. Rabbit one morning, "you may go into the fields or down the lane, but don't go into Mr. McGregor's garden." There speaks the eternal mother, and children recognize her, as well as the temptation of the forbidden garden. Here is a first book for the beginning reader which interprets life in terms which he can understand.

Choosing the Best Picture Books

Since a child's whole response to reading may well be conditioned by his first experiences with books, the choice of picture books and picture storybooks is important. From them a child learns to know and appreciate the value of color and the worth of firm, clear line. Proportion, design, and the style of individual artists are all absorbed unconsciously.

The first books, then, should be simple in line, clear in color, with not too many objects presented at one time. There must be feeling in the pictures as well as technical skill, for without emotion nothing touches the inner consciousness of the child and nothing remains in the memory.

Fine artists and writers have made a great contribution in these books, writing and drawing out of the best gifts of their minds and imaginations. Leslie Brooke, Randolph Caldecott, Elsa Beskow, Kate Greenaway, Wanda Gág, Robert McCloskey, and many others have created joyous worlds of text and well-drawn pictures which tell stories and teach children much wisdom of life How greatly these first books are loved! These are the books that are looked at again and again; these are the books that are carried off to bed and slept with like favorite toys Children are quick to feel their worth.

There are many books for little children, printed in bright colors that are "pretty" to look at But too often the color is all that such books have They say nothing to the mind of a child Their pages present no pictorial world in which the eye finds something fresh each time it scans the page. Wise parents of today are well aware of the worth of proper food for their children, and they give the same conscientious thought to choice where books are concerned. Nothing less than the best in books and pictures is fit to sustain the questing mind and spirit of a child.

Nonsense Rhymes and Poetry

Reading offers a child, at each successive stage of his development, the means by which he can help himself. When picture books are beginning to be left behind, and action is limited by "You mustn't" and "Don't touch that," there is the fascination of nonsense to explore. "Every healthy-minded person, big or little, wants to be nonsensical now and then," wrote Burges Johnson, in his introduction to 'A Little Book of Necessary Nonsense'. And here is Edward Lear, making up names for things that never were and combining them in a musical rhyme:

> Calico pie,
> The little birds fly
> Down to the calico-tree:
> Their wings were blue,
> And they sang "Tilly-loo!"
> Till away they flew;
> And they never came back to me!
> They never came back,
> They never came back,
> They never came back to me!

Sometimes the characters in Lear's little dramas are the common things that a child sees every day. This is the first verse of 'The Table and the Chair':

> Said the Table to the Chair,
> "You can hardly be aware
> How I suffer from the heat
> And from chilblains on my feet.
> If we took a little walk,
> We might have a little talk;
> Pray let us take the air,"
> Said the Table to the Chair.

Nonsense offers a release from restriction. It is laugh provoking because it is silly and absurd. The moments of stress in a child's day, the fits of stubbornness and anger can be charmed away by a bit of verse or nonsense recited at just the right time.

The rhymes of Edward Lear, the charming nonsense tales of 'When We Were Very Young' and 'Now We Are Six' by A. A. Milne are among the initial steps to a love of poetry. The child who has enjoyed them and the poetry of Mother Goose and other nursery rhymes is likely to love poetry all through life.

Poetry has its practical as well as its inspirational use. The rhythm and music of poetry can make discomfort endurable and while away the tedium of a long wait or a dull task. Poetry gives children a language that expresses what they themselves feel deeply. It can give them words with which to catch and hold a response to nature. Who has better described a sunrise than did Emily Dickinson in these verses:

> I'll tell you how the sun rose,—
> A ribbon at a time.
> The steeples swam in amethyst,
> The news like squirrels ran.
>
> The hills untied their bonnets,
> The bobolinks begun.
> Then I said softly to myself,
> "That must have been the sun!"

Approach to Realism

As children learn to read for themselves their eagerness increases with their skill. Fast on the heels of the desire to read nonsense comes the wish for realism. Boys and girls thirst for stories about children whose pattern of life mirrors their own. Simple stories of children going to school, playing in the snow, celebrating Christmas—all the ordinary experiences of child life in many parts of the world affirm their own judgment and experience. "Is it true?" they ask, meaning "Is it within the realm of possibility?"

This is the period too when children develop a great interest in science and the natural world. How seeds grow. How animals live. The many books of straightforward information, honestly and simply written, are of immense value to these children—true history and true science and true biography.

At this period children are filled with the desire to find out for themselves. Eagerly they scan the pages of the encyclopedia and lose themselves in a subject until some new interest absorbs their attention. "I worry about myself," one boy said to his mother. "Last week I was crazy about the stars and this week it's buried cities."

Fairy Tales and Myths

At the same time that the real world holds excitement for the child, the world of the traditional fairy tale may claim his devotion. The characters in the fairy tale move in a world rich in color, magic, and wonder. The child can easily identify himself with the youngest son who triumphs in the end or revel in the greatly deserved happiness of the eternal Cinderella. In the fairy tale the good is apparent and there is no mistaking the evil. Action is direct and, though it has its violence, there is a singular lack of suffering, for everything is symbolic rather than actual. The beauty of the princess is the beauty of every girl, the bravery of the prince the bravery of every boy, the dragon and giant represent the evil which everyone must overcome. The elemental themes of the fairy tale and the broad symbols they provide hold the child steadfast in his interest. These great tales represent the cumulated efforts of man in an early period of his development to interpret life in terms of his own imagination. Their great sincerity anchors the attention.

There is a relationship between the real world of nature and science and these imaginative tales. Who has not thought of the flying carpet of the 'Arabian

"Wanting to know" goes beyond a reaching for actual facts. There are also the unworded questions of childhood.

Nights' as he has watched the flight of an airplane? Anne Lindbergh, when she wrote about the experience of flying in her 'North to the Orient', turned to the fairy tale to express the miracle of flight. "Yesterday's fairy tale is today's fact," she says. "The magician is only one step ahead of his audience." And again, she speaks of the Greek myth of Icarus. "For Icarus, trying to scale the skies with his waxen wings, was merely an early *expression* of man's desire to fly."

The myths of the world are indeed the dreams of man. They represent his effort to foretell an unknown future, to explain an unknown past. Myths appeal to children for the sheer beauty of their stories—poetic, adventurous, and full of mystery. The wind, the flowers, the seas, the seasons—each has its myth to stir the heart. The child who knows the myth surrounding a subject as well as the scientific explanation of a fact has double value from his wisdom.

Interest in Hero Tales

The hero tales—the epic adventures of Odysseus and Arthur, Aeneas and Achilles, Cuchulain and Deirdre of the Sorrows—have the same appeal for the older boy and girl that the fairy tale has for the younger reader. There is an age in the middle years of childhood—the years from ten to twelve—when the shadow of a hero looms in the mind. Each of these heroes is the idealized composite of the qualities most admired by the culture which produced him. Each moves in a world less sure of success than that of the fairy tale. In these stories children begin to glimpse the peril of failure and the exultation of heroic action. These tales are an introduction to tragedy, since death defeats Robin Hood in Sherwood Forest and Roland at the pass. Stories of ideal action, they help to develop idealism in young readers and lead to an appreciation of greatness in men and women everywhere.

The years from ten upward are years of glorious inconsistency in reading. Boys and girls read in all directions. Enthusiasms change quickly. The latest and most technical book on television may be read almost simultaneously with 'Adventures of Pinocchio'. The reading of Jane Austen's novels may be varied with spells of reading fairy tales or career stories or school stories or books about horses or dogs. The variety of interest, the unevenness of taste, the concentration on one type of book for a period of time—all these are natural and healthy.

It is not necessary to own all the books that the children of a family need or want to read. Indeed it is good for them to establish in early life the habit of using a library, and in most communities books can be borrowed from a public or school library. But nothing takes the place of the ownership of some good books of the kind which will be read over and over again. The list of books entitled "Seven Stories High," found under Libraries in this encyclopedia, is unsurpassed for its awareness of children's interests as well as for its perceptive knowledge of books. A child who has been exposed to good reading all his young years will find his own way when he swims out to the deep pools of adult reading.

The Sharing of Books

Reading may be a personal pursuit, where one sits alone with a book and nothing comes between reader and author, or reading can be shared. It can establish a bond between two people. It can bring together a family of diversified ages and tastes.

This sharing of books can begin before a child can read for himself if adults will take the time to explore books with him. No other expenditure of time brings such returns to parents and children alike as the time taken to share a book This sharing brings an intimacy that comes in a period in the day when the authority of the parent is forgotten and the behavior of the child is not the first concern.

There are certain books which cry out to be shared in the family. The wit of Lewis Carroll's 'Alice in Wonderland', the fun and the beauty of 'Wind in the Willows', the high romance of the tales of King Arthur, the grandeur of the Bible—these are books to be read aloud, for their immortality is partly due to the beauty of their words. Many of the old ballads are favorites in some families, and washing dishes goes faster if accompanied by poetry. Some adults are reluctant to read with children because they fear the boredom of children's

Who has not thought of the flying carpet of the 'Arabian Nights' as he has watched an airplane in flight?

As Christmas approaches, there are the great Christmas stories to read aloud. And on Christmas morning new books are found under the Christmas tree.

books. But the great books of childhood, like all great books, offer fresh meaning each time they are read. Stories of Hans Christian Andersen are fairy tales to children; they are philosophy to adults. Many children's classics were originally written for adults but have been taken over by succeeding generations of children. Among these are Jonathan Swift's 'Gulliver's Travels' and Daniel Defoe's 'Robinson Crusoe'.

It is the moments that are shared which bring families together in a way that is never forgotten—the Christmases when everyone is home, the summer picnics; the family trips. Each day may yield its own portion of a shared experience through reading. Hour by hour and book by book, children may receive this great heritage; the joyous acceptance of books for pleasure, wisdom, and understanding.

READING *Becomes a* PERSONAL AFFAIR

If a cross section of good, adult readers from all over the country were interviewed, more than half would probably say that they could not remember when their interest in reading began since they had read from early childhood. A considerable number would recall that as children they had been eager to read but so few good books were available that they did not make any real start in reading until they reached high school or even college. Some would tell of being led to reading through timely introductions to interesting books.

One American boy reached the age of 12 without ever having read a book. His parents were Irish and were great storytellers, as were his aunts and uncles. They loved the theater and began taking the boy to see plays when he was six. One summer he was sent to a farm for a vacation. It rained steadily for two weeks so he could not go out of doors, and, of course, there were no storytellers and no theaters. But there was a well-filled bookcase to which he turned in sheer desperation. The first books read were Frances Hodgson Burnett's 'Little Lord Fauntleroy' and Mark

Twain's 'Joan of Arc'. The sun came out, but the boy read on—a history of Rome, several books of a popular boys' series, Swift's 'Gulliver's Travels', and so on until his vacation ended.

When he returned to the city, he continued his interest in the theater and in the family storytelling, but he also gave reading its rightful place in his life. This boy is now a man. He is familiar with the best in classical and contemporary literature and is a discriminating reader.

Values of Early Reading

Those boys and girls who have discovered the values and pleasures of reading before reaching their teens are fortunate. They are familiar with the uses of books, newspapers, and magazines and know where to look for information for a school assignment or to satisfy some personal interest.

The high-school senior who has kept a balance between fun and reading is apt to be popular on any college campus.

Through familiarity with the great classics of childhood, they have developed an appreciation of good writing which helps them to discriminate between good and poor adult books. They discover rather quickly that there is no hard and fast line between the reading of children and grown-ups. The boy or girl who has loved 'Alice in Wonderland' in childhood finds that next to the Bible, it is probably the one book most often quoted by adults. One who has enjoyed Kipling's 'Jungle Books' will read 'Kim' with equal pleasure but will doubtless return occasionally to the earlier favorites. 'Robinson Crusoe' is a natural gateway to the fascinating book world of adventure and exploration. It also is a book which one reads as an adult.

In his delightful introduction to the anthology, 'Reading I've Liked', Clifton Fadiman lists the ten books of "literary imagination produced by the English-speaking race" which he believes "will be most widely read and generally admired a hundred or five hundred or a thousand years from now." They are: the Plays of Shakespeare, 'Moby-Dick' by Herman Melville, 'Gulliver's Travels' by Jonathan Swift, 'Robinson Crusoe' by Daniel Defoe, 'Alice in Wonderland' by Lewis Carroll, 'Huckleberry Finn' by Mark Twain, 'Little Women' by Louisa M. Alcott, some novel of Charles Dickens, probably 'David Copperfield' or 'Pickwick Papers', 'Treasure Island' by Robert Louis Stevenson, and 'The Mother Goose Rhymes'. Of these books all but those of Shakespeare, Melville, and possibly Dickens are children's favorites. All, with the possible exception of Mother Goose, are found in high-school libraries. It is because these books are met again and again all through life that Fadiman believes they will be immortal.

The Reader Who Gets a Late Start

Those boys and girls who have reached the teen age without a background of good reading may begin with some of the children's or young people's classics, or they may start with contemporary books. If the older books have been missed, they should be picked up one by one and read along with the others.

Sometimes one has to set out deliberately to develop a taste for reading much as someone else may determine to learn to swim. Just as the first strokes of a swimmer are the easy ones which merely keep him afloat, so the first books may be those which are closest to the normal interests of the individual, for these are usually the easiest for him to read. These first books may be about baseball or flying or horses or dogs. They may be books of adventure or they may tie in with some hobby.

Suppose a boy who is intensely interested in baseball starts his reading with John Durant's 'Story of Baseball', which is full of pictures and has only a short text. From there he might go on to Joe DiMaggio's 'Lucky to Be a Yankee' or Frank Graham's 'Lou Gehrig'. Instead of continuing to read about famous ballplayers, this is a good time to change pace and read, say, that fascinating tale of modern adventure, 'Kon-Tiki' by Thor Heyerdahl, a true story of a trip on a balsa raft from Peru to the South Sea Islands. A next step might be Robert Louis Stevenson's 'Treasure Island', one of the greatest sea stories of all times.

It is helpful if the beginning reader has the advice of someone with a knowledge of books and people. This adviser may be a librarian, a teacher, or one of a dozen other informed persons with whom young people come in contact. Good advisers can aid at this point because they can make certain that these first books are interesting and well written. They can also suggest books which will serve as steppingstones from one field of interest to another.

Broadening Interests in Reading

Even before entering high school, boys and girls should begin to relate one form of literature to an-

other. One who has enjoyed Andersen's fairy tales in childhood surely has developed some curiosity about Hans Christian Andersen the man. There are in this encyclopedia interesting biographies of Hans Christian Andersen, Rudyard Kipling, Charles Dickens, Jonathan Swift, and other great writers, which serve as introductions to the field of biography. Longer biographies of these writers are available in most libraries. When a reader has finished a good story which has a setting in a foreign country, he may wish to read a book or article about that country in order to prolong his enjoyment and add to his store of information.

The article on Mythology in this encyclopedia will be appreciated after some collections of myths have been read because it tells how myths began and establishes their place in literature. The article on American Folklore is equally interesting since it gives the background for a full enjoyment of stories of Pecos Bill, Paul Bunyan, and other characters well known to every reader of folk tales.

More adults would enjoy poetry if they had read poems along with other things when they were young. There are poems to fit any taste or mood. There are narrative poems about historical events. There are poems about nature and Indians and animals. There are poems as full of humor as any story that was ever written and patriotic poems as stirring as a Sousa march. Poets have written about skyscrapers, steel mills, and other man-made things, and Rachel Field even wrote a gay little poem entitled 'Taxis'.

Anyone who loves music and likes to dance should also enjoy poetry, for all three forms of art make the greatest appeal to one with a sense of rhythm. Originally poetry was always sung or chanted and to enjoy a poem one has to listen for its music. That is why it is often suggested that poetry be read aloud.

The best way to approach poetry is to look for poems that one likes, using some anthology like Carhart and McGhee's 'Magic Casements' or Untermeyer's 'This Singing World.' In his article on Poetry in this encyclopedia, Stephen Vincent Benét has given one of the finest introductions to poetry that has been written.

Reasons for Reading

There are probably as many reasons for reading as there are kinds of books. A person may read for information or just for fun. He may read to gain or sustain religious faith or for relief from a personal problem. One may read in preparation for travel or to learn about some country which he never expects to visit. The list might go on indefinitely.

Sometimes the unexpected values gained from reading good books overshadow the fulfillment of the original purpose. An American girl may, for instance, read Papashvily's 'Anything Can Happen' for its sheer fun. And even as she is laughing at the predicaments of this Georgian immigrant, she gains a sudden understanding of the problems of a classmate who was born abroad and has entered high school without too much knowledge of the United States. A boy may begin one of the fine biographies of Lincoln in order to learn more about the Civil War. As he reads, he may be so impressed by Lincoln's lack of animosity toward those who disagreed with him that he himself becomes less opinionated and more tolerant of the views of others—and this without surrendering any of his real principles.

Cumulative Values of Reading

The cumulative values of reading are most important of all. These cannot be measured book by book but can only be discerned by looking back over a fairly long period in which a proportionate amount of time has been spent in reading. One who has read widely and well should have become a wiser person with better balanced emotions. A reader is or should be more understanding than the nonreader. Powers of imagination and intuition are developed by reading. The reader gradually increases his vocabulary. He becomes a better conversationalist, not because he quotes continuously from books, but because reading has given him a background which enables him to discuss many topics that arise in even a casual conversation.

Concentration on the thing one is doing is important to success. This applies equally to football and reading.

In his book 'The Importance of Living' the famous Chinese philosopher Lin Yu-t'ang says: "The man who has not the habit of reading is imprisoned in his immediate world in respect to time and space... he is limited to contact and conversation with a few friends and acquaintances, and he sees only what happens in his immediate neighborhood... But the moment he takes up a book he enters a different

world, and if it is a good book he is immediately put in touch with one of the best talkers of the world."

Reading Is a Personal Matter

When all is said and done, reading ultimately becomes a personal affair. At the period when one is trying to decide what books to read and what to let alone, guidance may help, but sooner or later a reader is left to follow his own inclinations.

A librarian or teacher may tell a younger reader what she thinks of a book, but she can never tell him what he will think of it. Often a reader is discouraged because he does not like some book which has been highly recommended. In such a case, it is best to lay the book aside. Later the book may be read with enjoyment or the reader may never like it. Individuals do not react in exactly the same way toward all people. Why should they think alike about all books?

These disagreements are all right in the case of an occasional book. If a reader finds himself disliking too many of the books that are recommended, he should begin to check on the kind of books that he has been reading. Perhaps he has fallen into the rut of mediocre reading. Mediocre books, like weak friends, flatter one's ego because they offer no challenge leading to broader thinking or acceptance of new ideas.

Developing Book Judgment

No one has ever succeeded in developing a perfect formula for determining whether or not a book is good. As soon as one attempts it, he runs into questions such as "good for whom?" and "good for what?" May Lamberton Becker says: "Youth readily recognizes sincerity and vitality. It will be enough for one at this stage to ask himself two questions. The first is 'What is this author trying to say, and is he saying it?' The second is 'What audience is he trying to reach and is he reaching it?' Much ink is spilled, much effort wasted, in scolding an author for not saying what he did not mean to say or for not satisfying experts with a book meant to enlighten beginners."

Critical judgment of books develops slowly with experience in reading. A fine biography which is an interesting and fair portrait may in the reader's mind become a measuring stick by which other biographies are tested. After one has read a good novel in which characters act like real people, one by a less skillful writer will seem weak and uninteresting.

If a young reader finds that every now and then he is enjoying some good book that he did not appreciate a year before, he is on his way to becoming a discriminating reader. It is more important to like a good book than it is to be able to tell why you like it.

Reading as an Art

Just as familiarity with a piano keyboard and coordination of the two hands are the first steps in the development of a pianist, so mastery of the mechanics of reading is only the beginning of the process of becoming a reader.

Long before reaching high school most boys and girls have acquired the ability to read by phrases and lines, instead of word by word. Usually this facility comes through practice. Through research and tests experts have developed methods for helping those who find it unusually difficult to learn the mechanics of reading.

Only when a person has acquired such skill in reading that he is no longer conscious of the mechanics is he completely free to read with enjoyment and understanding. At this point reading ceases to be a technique and begins to be an art.

Finding Time for Reading

In this modern world many worth-while interests seem to compete for one's time. No one should withdraw from life into a world of books but some time for reading should be deliberately planned.

One man who heads an important business has budgeted his time most satisfactorily. He is interested in sports but likes football best. So he attends the important football games in his area and takes time only for the high lights of other sports events. He enjoys television and radio but tunes in only for certain programs. He is equally selective in his reading and reads a surprising number of important books from each year's crop.

Reading is not the only worth-while method of communication, but books offer one great advantage over motion pictures, television, and radio. The wisdom gained through the reading of good books need never fade or be lost. If a book makes a strong impression, it can be read again wholly or in part. Some people who have access to good libraries make it a rule to purchase only those books which they use frequently or wish to read a second time. Perhaps the desire to own a book is the best test of its value to a reader.

BIBLIOGRAPHY FOR READING

Reading Techniques and Approaches

Flesch, Rudolf. Why Johnny Can't Read (Harper, 1955).
Gans, Roma. Reading Is Fun (Teachers College, 1949).
Gray, W. S. On Their Own in Reading (Scott, 1948).
Witty, P. A. How to Become a Better Reader (Science Research, 1953).

Children and Their Books

Arbuthnot, M. H. Children and Books (Scott, 1947).
Becker, M. L. First Adventures in Reading (Lippincott, 1947).
Duff, Annis. Bequest of Wings (Viking, 1944).
Eaton, A. T. Reading with Children (Viking, 1940).
Frank, Josette. Your Child's Reading Today (Doubleday, 1954).
Hazard, Paul. Books, Children & Men (Horn Book, 1948).
Johnson, Edna and others. Anthology of Children's Literature (Houghton, 1948).
National Council of Teachers of English. Adventuring with Books: an Annotated and Graded List of Books for Use with Children in the Elementary Grades (The Council, 1950).

Guides for Young People

Becker, M. L. Adventures in Reading (Lippincott, 1946).
Munson, Amelia. An Ample Field (A.L.A., 1950).
National Council of Teachers of English. Books for You: a High School Reading List (The Council, 1951).
National Council of Teachers of English. Your Reading: a List for Junior High Schools (The Council, 1954).
Roos, J. C. Patterns in Reading (A.L.A., 1954).

Reading from the Adult Angle

Drew, E. A. Enjoyment of Literature (Norton, 1935).
Stefferud, Alfred. Wonderful World of Books (Houghton, 1952).
Wagenknecht, E. C. Preface to Literature (Holt, 1954).

READING (*rĕd'ĭng*), **PA.** When William Penn was establishing the present state of Pennsylvania he purchased from the Indians a tract of land "two full days' journey" up the Schuylkill River. On this spot two of Penn's sons, Thomas and Richard, founded the city of Reading in 1748. Today this city is one of the most important industrial centers in the state and the county seat of Berks County.

Located 58 miles northwest of Philadelphia, Reading has fine transportation facilities. The city claims the world's largest full-fashioned hosiery mill and the nation's largest brick-burning kiln and single-unit foundry. Other important products are textiles, machinery, food, clothing, and transportation equipment. In addition there are large locomotive repair shops.

The Schuylkill River flows past Reading on the west, while the Neversink Mountains and Mount Penn flank it on the east. The city serves as the trading center for a rich farming community populated by many "Pennsylvania Germans." Reading was incorporated as a city in 1847. It is governed by a commission. Population (1950 census), 109,320.

REAPING MACHINES. The earliest farmers probably reaped their grain with stone sickles. Later, metal scythes and cradle scythes were used. These were the chief reaping tools until the 1800's. Then the development of the reaping machine revolutionized agriculture and greatly increased the amount of grain one farmer could harvest in a single day.

Among the various reaping machines devised, the most important was Cyrus McCormick's American reaper, invented in 1831. Today McCormick machines are widely used throughout the world (*see* McCormick).

The first machine was a horse-drawn reaper which only cut the grain. A later improvement carried the grain to men riding on a side platform. Here the grain was bound with twine by hand and the sheaves dropped to the ground. Then came the self-binding reaper that cut, bound, and dropped the sheaves. The sheaves were later assembled at a threshing machine.

The most modern harvester-thresher is the combine. It cuts off the tops of the grain, threshes the heads, and drops the cleaned grain into a container. These automatic combines harvest wheat, oats, barley, rye, soybeans, and rice. (*See also* Threshing.)

REBUILDING *the* NATION *after the* CIVIL WAR

RECONSTRUCTION PERIOD. The Union victory in the Civil War forever settled the grave national problems of secession and slavery. The cost of this settlement, however, was staggering. More than half a million men had died and another half million had been wounded, some of them crippled for life. In terms of money, the loss was equally enormous. The annual expenses of the federal government rose from 63 million dollars a year in 1860 to almost 1,300 million dollars in 1865. At the same time the national debt climbed from 65 thousand dollars to more than $2\frac{3}{4}$ million dollars. (*See* Civil War, American.)

In the North, the currency had been made unstable by frequent issues of paper money. These "greenbacks" now had to be replaced by "sound" currency backed by gold or silver. War industries had to be converted to peacetime production. Thousands of veterans and others had to find new work because their old jobs had been filled or, in many cases, abolished by the increased use of machinery.

The greatest problem of all was to reconstruct the South. Here the economic loss was almost beyond calculation. Confederate currency and credit were worthless; and United States money virtually nonexistent. Squeezed by the wartime naval blockade and devastated by the years of bitter fighting, huge areas lay in decay or utter ruin. From Virginia to Texas, cities had been laid waste by fire and bombardment. Guerrilla bands roamed and looted the countryside where great plantations lay deserted for want of labor, tools, livestock, and seed. Transportation facilities, especially railroads, and communication lines were almost completely destroyed.

Symbolizing the plight of the Confederate veteran is this painting by William Sheppard—a soldier's return to a ruined home.

LIKE A BOMBED CITY OF WORLD WAR II

When the Union army entered the abandoned Confederate capital of Richmond on April 3, 1865, they found a city devastated by fire and bombardment.

Probably the greatest problem of all was the severe shortage of manpower in the most needed fields—skilled labor, administration, and professional services. This problem was made worse by the fact that the prewar South had been dominated by the so-called country gentlemen. This class was now largely discredited and often penniless. In addition, the sudden abolition of slavery had freed hundreds of thousands of Negroes who now found themselves incapable of making a living as free workers.

Yet despite these great handicaps, the waste and destruction of war had to be remedied. The Negro had to be taught to work as a free laborer and to adjust himself to his new status in society. The old plantation system had to give way to one of small farms operated by tenants on shares. Manufacturing had to be introduced to replace the abnormal dependence upon agriculture, especially cotton growing.

Johnson's Reconstruction Policies

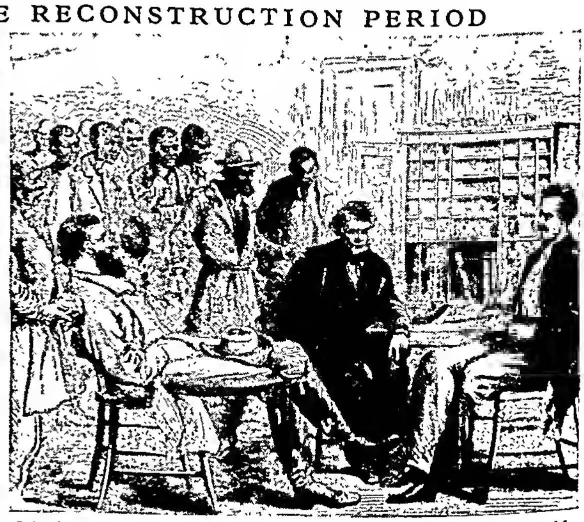
The great problems of reconstruction were aggravated by disputes over constitutional issues in the federal government. President Lincoln had assumed that since secession was unconstitutional, the Southern states had really never left the Union. He also believed that it was the president's responsibility to direct reconstruction efforts (*see* Lincoln, Abraham). These views were challenged by a group of radical Republicans sometimes called the "vindictives." These Radicals were determined to treat the former Confederacy as "conquered provinces" whose punishment would be determined solely by Congress.

Had Lincoln lived, it would have required all his political skill to carry out his reconstruction policies. Under President Johnson there was no hope of adopting a moderate attitude toward the South. Johnson was an earnest and able man but he was himself a Southerner (from Tennessee), and he had a stubborn temperament that put him at a serious disadvantage in dealing with his political opponents.

During the summer of 1865 Johnson established the basic reconstruction plan outlined by Lincoln. He proposed to allow the citizens of each seceded state to re-establish their own governments whenever enough of them had taken the necessary oath of allegiance to the United States. The states must annul their ordinances of secession, repudiate the debts they had incurred in fighting the war, and abolish slavery. By the time Congress convened in December every state except Texas had fulfilled these requirements (Texas did so four months later). Johnson announced that the Union had been restored and each state was entitled to its full political rights. With the help of several of these reconstructed states the 13th Amend-

TWO BITTER ISSUES IN THE RECONSTRUCTION PERIOD

In 1868 the Radical-dominated House voted to impeach President Johnson, the only such charge ever made against a president. Here the Senate, sitting as a court, is voting his acquittal.



The Freedmen's Bureau operated from 1865 to 1870. Created by Congress to aid former slaves, it was denounced by President Johnson and severely criticized in many parts of the nation.

LEADER IN WAR AND IN PEACE

After the war the Confederate Commander in Chief Gen. Robert E. Lee became president of Washington (and Lee) College.

ment, abolishing slavery, was ratified and proclaimed in effect Dec. 18, 1865.

Congress Takes Over Reconstruction

In December 1865 the 39th Congress convened and immediately rejected Johnson's work. Led by Thaddeus Stevens of Pennsylvania in the House and Charles Sumner of Massachusetts in the Senate, Congress refused to seat Southern representatives and senators (*see* Sumner). A long struggle between the president and Congress then followed in which Congress gained the upper hand and the South had to submit to a second political reconstruction (*see* Johnson, Andrew).

One of the first acts of the new Congress was to establish the Freedmen's Bureau to care for the freed Negroes and the abandoned lands in the South. The act also provided for a military commission to try persons accused of depriving the freedmen of their civil rights. This measure was an answer to the "black codes" adopted by Southern legislatures to bind the former slaves to the land by vagrancy and apprenticeship laws. Johnson vetoed the bill but Congress passed it over his veto.

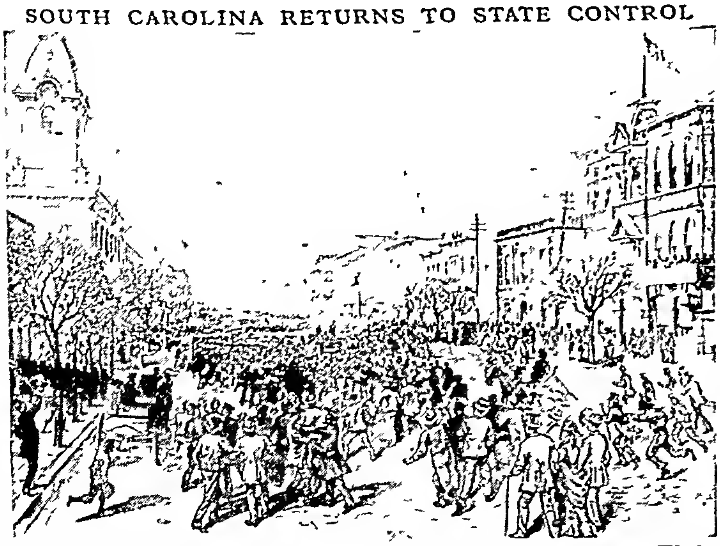
Congress then passed the 14th Amendment and submitted it to the states for ratification. This amendment defined national citizenship for the first time and guaranteed full civil rights to the freedmen. Each Southern state was required to ratify the amendment as a condition of restoration to the Union. Tennessee, which was controlled by Radicals, complied with this provision and was readmitted to the Union July 24, 1866. The ten other Southern states rejected it, however, and the amendment did not take effect until 1868.

In the Congressional elections of 1866, the Republicans won a two-thirds majority in both houses and assumed complete control over reconstruction policies. In 1867 Congress passed three reconstruction acts over President Johnson's veto. The quarrel between the executive and legislative branches of the government became so bitter that Johnson was impeached by the House of Representatives the following year. He was acquitted in the Senate by the narrow margin of one vote short of the two thirds necessary for conviction (35 votes for conviction; 19 for acquittal).

The 1866 reconstruction measures passed by Congress divided the South into five military districts subject to martial law during a probationary period. The acts also provided for Negro suffrage and the disfranchisement for treason of nearly all the leading Southern white men. Each Southern state was required to call a convention to adopt a new constitution.

In the next four years Negroes and Negro-white coalitions won control of every state government in the South. Southern whites who co-operated with the Radicals were called "scalawags." Northerners who went South to take part in reconstruction were known as "carpetbaggers" (because it was said that they came South with all their worldly possessions in carpetbags). Most of the state offices were taken over by illiterate Negroes and scalawags. Under this leadership seven states—Arkansas, Alabama, Florida, Georgia, Louisiana, North Carolina, and South Carolina—were readmitted to the Union in June 1868. In Georgia, however, Negroes were expelled from the state legislature as soon as Federal troops were withdrawn. Military rule was reimposed and it was not until two years later that Georgia was again turned over to local administration. Meanwhile, by 1870, Mississippi, Texas, and Virginia had been granted readmission into the Union. In that year also, during the administration of President Grant, the 15th Amendment, granting the Negro the right to vote, became effective (*see* Grant).

SOUTH CAROLINA RETURNS TO STATE CONTROL



Most of the people in Columbia, S. C., rushed out to meet Governor Wade Hampton when he took control of the state government in 1877. He was South Carolina's first postwar governor elected by white citizens.

Effects of Reconstruction in the South

The new governments in the Southern states immediately plunged into an orgy of corruption and waste that further impoverished the

South. In South Carolina the public debt rose from 7 million dollars to 29 million dollars in eight years. In Louisiana the public debt jumped from 11 to 50 million dollars and the state tax burden increased 500 per cent (to become three times the tax rate in New York for the same period). Conditions in other states were much the same. Some of this money was used for increased public services and for rebuilding devastated areas but much of it was squandered needlessly or stolen. At the same time property values dropped sharply.

Under these incompetent state governments there was little protection for life or property. In some places irresponsible Negroes became a definite social menace. It was this condition which prompted the rise of secret orders of Southern whites such as the Knights of the White Camelia and the Ku Klux Klan. These groups were organized to frighten the freedmen and their carpetbagger leaders into surrendering control to white men of the South.

To combat such societies, Congress placed Southern elections under national control in 1870; and in the following year authorized the president to use the Army to suppress these groups. Such actions, however, proved effective only as long as Federal troops were stationed in the South. Once the threat of military force was gone Southern white men assumed full control, and the carpetbag political and social orders declined rapidly.

Amnesty and Slow Recovery

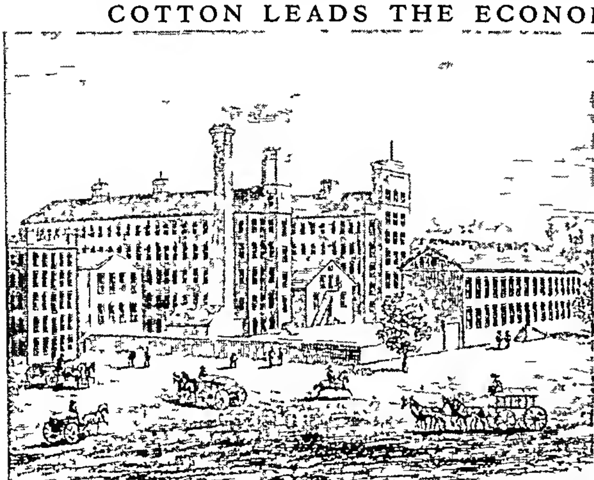
In 1865 President Johnson had granted amnesty to Confederates who would take the oath of allegiance to the United States. There were several classes prohibited from accepting this amnesty, such as those who held more than $20,000 in taxable property. These people, however, could receive pardon through special petition to the president. Two years later the Supreme Court declared unconstitutional federal and state loyalty oaths which barred ex-Confederates from pursuing certain vocations. Then in 1872 Congress passed an Amnesty Act, which removed restrictions from all but the most prominent leaders of the Confederacy (about 500 in all).

The greatest hero of the Confederate States, Gen Robert E. Lee, took the lead in demonstrating the need for peace and national unity. In September 1865 he became president of Washington College (later renamed Washington and Lee) at Lexington, Va. (*see* Lee, Robert E.). One of Lee's corps commanders, Gen James Longstreet, joined the Republican party and secured federal appointments to various jobs until his death. Wade Hampton, a capable cavalry commander, operated plantations until 1876, when he was elected the first Democratic governor of South Carolina after the war. Another cavalry leader, Joseph Wheeler, served 15 years in the House of Representatives (from Alabama) and during the Spanish-American War became a major general of volunteers. (*See also* Davis, Jefferson; Stephens.)

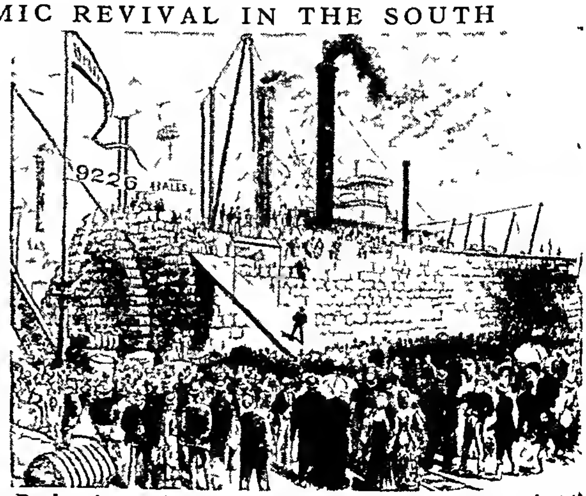
By 1870 there was definite economic progress in the South. Cities were largely rebuilt, lumbering and mining resumed, and manufacturing undertaken, especially in the Piedmont region of the Southeastern states. Cotton was bringing high prices and in 1870 more than 4 million bales were produced, a greater number than before the war. The Negro became better adapted to his status as a freedman. Helping the Negro make the sharp adjustment from slavery to freedom were such Negro schools as Hampton Institute, in Virginia; Howard University, in Washington, D. C.; and Fisk University, in Tennessee.

Gradually Federal troops were withdrawn from the South; the last, from Louisiana on April 24, 1877. Thus the period of formal reconstruction came to an end during the administration of President Grant's successor, Rutherford B. Hayes (*see* Hayes). Full economic recovery took much longer, however, and some political and social outgrowths of the war and reconstruction period are still in evidence today (*see* Political Parties; United States History).

COTTON LEADS THE ECONOMIC REVIVAL IN THE SOUTH



Despite the distress and hardships of reconstruction, the economy of the South grew steadily stronger. This is a thriving cotton factory that was operating in Columbus, Ga., by 1874.



During the 1870's the South was producing more cotton than it was before the war. This drawing shows a record load of 9,226 bales of cotton arriving on a river boat at New Orleans

SYMBOL *of* SERVICE *in* WAR *and in* PEACE

The Red Cross Is Trained and Ready for Disaster Relief

RED CROSS. Traveling through northern Italy in 1859, a young Swiss businessman named Henri Dunant happened to be at the scene of one of the most savage battles in history—the battle of Solferino. Appalled by the number of wounded and dying soldiers, Dunant recruited volunteers from nearby towns to help relieve the soldiers' suffering. Later he wrote a pamphlet, 'A Memory of Solferino', in which he suggested a world conference "to form societies for the purpose of having care given to the wounded in wartime by zealous, devoted and thoroughly qualified volunteers." The international Red Cross organization grew out of Dunant's work.

Meeting at Geneva, Switzerland, in 1864, the representatives of 14 nations drew up a treaty called the Geneva Convention. This provided for the protection of societies to be organized in time of war for the care of the wounded. During peace their efforts were to be devoted to preparing medical supplies and training volunteer nurses. In honor of Dunant, the flag of his native Switzerland, with its colors reversed—a red cross on a white field—was adopted as the symbol of protection. In Mohammedan lands the cross is not used, and various symbols are used in the different countries. The Turkish organization, for example, uses a red crescent and is known as the Red Crescent Society.

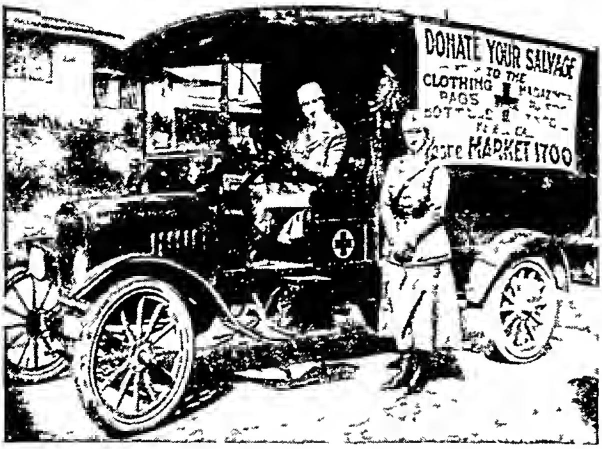
Some of the representatives at the first Geneva meeting questioned the idea of allowing civilians in military areas, fearing they might be used as spies. Florence Nightingale, who had helped care for the wounded English soldiers in the Crimean War, had encountered this objection. In the American Civil War, however, the voluntary Sanitary Commission, a civilian organization, helped nurse the Union troops. The experiences of the Sanitary Commission quieted the objections to allowing civilians in battle areas. Soon the Red Cross was organized on an international scale, operating in peace and war alike, without religious or political discrimination.

The International Red Cross consists of the national Red Cross Societies, the International Committee of the Red Cross, and the League of Red Cross Societies. Each of the national Red Cross societies is an independent organization. The societies communicate through the International Red Cross Committee in Geneva, Switzerland, and hold meetings every few years. This committee is a neutral body composed of Swiss citizens. The League of Red Cross Societies co-ordinates peacetime programs. In 1949 members of the International Red Cross liberalized the Convention. New rules provided protection of civilians in occupied nations, set up neutral medical zones, and gave prisoner-of-war rights to partisans.

Organization of the American Red Cross

The United States was represented at the Geneva conference in 1864, but it did not sign the Red Cross Convention until 18 years later. Clara Barton, whose service to soldiers near the front during the Civil War had earned her the name "angel of the battlefield," organized the American branch in 1881 and became its first president (*see* Barton). The next year President Arthur signed the Convention. The first local chapter was established at Dansville, N. Y. In 1898 President McKinley asked Clara Barton to head a Red Cross mission to Cuba. When the Spanish-American War began, the Red Cross immediately concentrated all its efforts on war work. It was in this war that graduate nurses served the military forces for the first time in America's history.

ON THE HOME AND BATTLE FRONTS IN TWO WORLD WARS



Home-front volunteers in the World War I motor corps collected scarce materials for the war effort (left). In World War II the Red Cross collected 13 million pints of blood to be used for battlefield casualties in the form of lifesaving blood plasma (right)

In 1905 the organization was reincorporated under a charter from Congress as the American National Red Cross. The president of the United States acts as its chairman and he appoints the national president and eight of the 50 members of the board of governors. Membership is open to any citizen or resident of the country. To finance its activities, the American society makes national campaigns for funds from the public. Its accounts are audited by the Department of the Army. In time of war Congress appropriates large sums of money for the purchase of food for the Red Cross to distribute among refugees. Food, clothing, and medical supplies are sent all over the world.

Red Cross Wartime Services

The methods of modern "total war" place new responsibilities on the Red Cross. Civilians as well as armed forces become military targets. Besides the enormous task of helping soldiers, sailors, and airmen, the society is called upon to extend relief to entire populations suffering from enemy air raids.

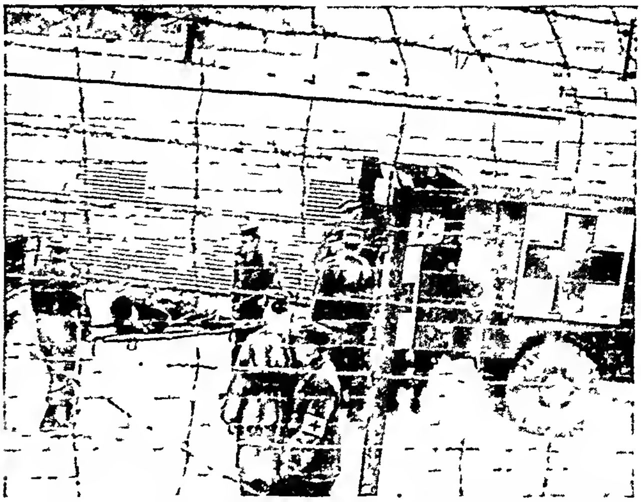
Seventy-one national Red Cross societies all over the world, with a membership of more than 100 million persons, work together to perform a number of additional wartime services. They distribute medical equipment and supplies of all kinds and provide rest stations where soldiers can obtain refreshment and lodging. The nursing service trains thousands of nurses to tend the wounded. In addition to ordinary medical care, the Red Cross dispenses blood plasma for emergency transfusions. It directs evacuation and cares for refugees. It handles the legitimate and necessary personal correspondence with residents of enemy or enemy-occupied territories. A recreation corps entertains soldiers in hospitals. Another bureau searches for missing men and gathers information concerning the sick, the wounded, and the dead. Messages are transmitted between prisoners of war

WHEN WARS ARE OVER, THE RED CROSS CONTINUES ITS WORK

The roof gone and her household goods scattered by a tornado, a disaster victim reports her needs to a Red Cross worker (left).

A Red Cross swimming instructor (right) gives a helping hand to a beginning swimmer. Note the instructor's Water Safety badge.

THE AMERICAN RED CROSS IN KOREA



Both men and women serve as fieldworkers in modern war, some in areas still under fire. American combat soldiers called Red Cross clubmobile girls (left) the "powder-puff patrol." Red Cross observers supervised Korean prisoner-of-war exchange (right).

and their families, and food and other supplies are sent to the prisoners. The home service looks after soldiers' families, giving them financial assistance when necessary.

When wars are over, the Red Cross assists in returning prisoners to their own countries. It helps the disabled to readjust themselves by giving them loans and free training in crafts and assists civilian populations in reconstructing their communities.

Red Cross Work in Peacetime

In peacetime, relief to the victims of disaster is an important part of Red Cross work. In 1889, for example, when a dam above Johnstown, Pa., gave way sending a wall of water 75 feet high pouring down upon the city, the Red Cross took care of the sufferers. In 1906, when one third of San Francisco was burned, the Red Cross rushed food and clothing to the homeless. Wherever disaster strikes, Red Cross workers are there to help. The American Society maintains a permanent staff to direct its great army of volunteers in any emergency. Public utilities, newspapers, radio, television, railroads, planes, and ships are always at its command.

HELPING A DISABLED VETERAN

Red Cross nurse's aides and Gray Ladies help speed the recovery of disabled war veterans with handcraft projects.

In 1910 the Red Cross launched its program for instructing civilians in first aid. A lifesaving and water-safety service was established in 1914 (*see* First Aid; Safety). In 1909 the Red Cross nursing service was organized. Today it is supplemented by a voluntary hospital and recreation corps, called the Gray Ladies. Instruction in home hygiene and in care of the sick was added to the nursing program in 1908. In 1912 the Red Cross town and country nursing service, which later became the Red Cross public health nursing service, was begun. Volunteer special services also include sewing, knitting, and making surgical dressings; transcribing books into braille for the blind; sponsoring courses in nutrition; and operating canteens during disasters. The volunteer Motor Corps carries Red Cross workers to meetings as well as to disaster-relief assignments. Beginning in 1940 volunteer nurse's aides were trained to assist nurses in hospitals.

In 1937 a blood donor service was started. This was expanded in World War II and in the Korean war and continued as a national blood donor program in peacetime. In 1953 and 1954 the Red Cross provided gamma globulin to the National Foundation for Infantile Paralysis for infantile-paralysis-prevention tests throughout the United States.

How the Junior Red Cross Helps

In 1917 President Wilson issued a proclamation inviting young people in the United States to form a Junior Red Cross similar to those in Australia and Canada. Leading educators co-operated in the movement. Today members of the Junior Red Cross, children from kindergarten through high school, number about 20 million in the United States and more than twice that many throughout the world.

American Junior Red Cross members plan entertainments for hospital patients and for children and

THE JUNIOR RED CROSS ALSO HELPS

A Junior Red Cross member checks salvaged books with a schoolman following a tornado which destroyed the school.

elderly people in institutions. In sewing and shop classes in schools they make supplies such as bibs, food carts, lapboards, party decorations, and favors for hospitals and other institutions. "Juniors" help in blood centers. They work in canteens, in chapter offices, and alongside other volunteers in disasters. In swimming and water safety they take an active part as students and as instructors' assistants. Juniors also participate in leadership-training centers and in national area councils to plan and conduct their own activities. They are active at Red Cross conventions in floor discussions and as members of service panels.

In their schools, Junior Red Cross members promote friendship and understanding with young people in other lands by the exchange of gift boxes, international correspondence, school art, and music. Through the National Children's Fund, Junior Red Cross members contribute supplies to children who are victims of disaster, famine, political unrest, and war.

RED RIVER OF THE NORTH. This river is noteworthy because it comes very near to dividing North America in two. Its sources lie only a short distance from those of the Mississippi; yet its waters ultimately find their way to Hudson Bay.

The Red River of the North (so called to distinguish it from the Red River of Louisiana) is 545 miles long. It starts at the junction of the Otter Tail and the Bois de Sioux rivers at Breckenridge, Minn. Flowing northward, it forms the boundary between Minnesota and North Dakota, then enters Manitoba, where its waters contribute to the flow through Lake Winnipeg toward the north. The Otter Tail rises in west central Minnesota. The much larger Bois de Sioux comes out of Lake Traverse. This lake reaches within a mile and a half of Big Stone Lake, which leads through the Minnesota River to the Mississippi. Explorers carried their canoes across at this point to go from the Mississippi to the Red River system.

The Red River valley was once the muddy bed of ancient Lake Agassiz, which covered a huge area during the Ice Age. Almost entirely flat, its rich, black soil free from stones and tree stumps, this valley is now one of the world's great wheat-growing regions.

In the Red River valley occurred one of the tragic episodes of Canadian history, the Red River rebellion of 1869. In that year about 10,000 half-breeds, or *métis*, who had settled in the valley, rose in rebellion against the Canadian government, which had just acquired this region with the rest of the immense possessions of the Hudson's Bay Company. A provisional government was established by the rebels at Fort Garry (now Winnipeg), headed by Louis Riel. A force under Sir Garnet Wolseley crushed the rebellion the following year, and Riel fled to the United States. Following a subsequent uprising in 1885, in which Riel played a leading part, he was tried and convicted of treason and hanged.

RED SEA. This busy sea lane between the Indian Ocean and the Mediterranean has for centuries been one of the world's greatest trade routes. Since the days of the Phoenicians, nations have struggled to control its waters and the rich traffic between Europe and the Orient that flows through it. After Great Britain gained possession of India and Australia, the Red Sea became a vital link in British commerce.

It lies like a narrow trench, 1,200 miles long, between the Arabian peninsula and the northeast coast of Africa. From a maximum width of 250 miles, it narrows to 20 miles at the southern end, where the Strait of Bab el Mandeb (Gate of Tears) leads into the Gulf of Aden and the Indian Ocean. On the north the Red Sea forks into two prongs—the Gulf of Aqaba on the east, the Gulf of Suez on the west. Between the prongs lies the wedge-shaped Sinai Peninsula. The Gulf of Suez reaches to within 100 miles of the Mediterranean. The intervening strip is called the Isthmus of Suez.

For 2,000 years cargoes were carried overland from sea to sea by camel caravan. Then in 1869 a canal was cut across the isthmus, and the Red Sea took first rank as a commercial highway (*see* Suez Canal). The shore to shore traffic consists chiefly of boatloads of Mohammedan pilgrims from Africa bound for Mecca. They land at the Arabian port of Jidda.

The Arabian coast is a narrow sandy plain, backed by barren coral hills and high limestone ridges. On the African side lie the broad deserts of Egypt and the Sudan and the arid tablelands of Ethiopia. Navigation of the sea is difficult and dangerous. Jagged, hidden coral reefs abound. Sudden squalls are common and there are few safe harbors. The heat is often exhausting. The waters have an average temperature of 80° F. and evaporate so rapidly that the sea is excessively salty. Because of red algae, the color of the water at times is actually red. Except in the shallow Gulf of Suez, the average depth is 1,500 feet.

The Red Sea is famed, according to Bible accounts, as the sea crossed miraculously by the Israelites fleeing Egypt (Exod. xiv). Archaeologists have discovered evidence, however, that the crossing was made instead at a body of water near Great Bitter Lake north of Suez and the Red Sea.

REED, Walter (1851–1902). One of the leaders in conquering the dreaded disease yellow fever was Walter Reed. Until his time yellow fever ravaged tropical and coastal cities, killing thousands of people in yearly epidemics. As head of the United States Army Yellow Fever Commission, Reed led dramatic experiments to learn how the disease was transmitted. Reed and his co-workers proved that mosquitoes carried yellow fever, and so opened the way for its control in all communities where precautions are observed.

REED AND HIS MEN BATTLE YELLOW FEVER
This painting by Dean Cornwell depicts some of the heroes in the yellow fever fight. Dr. Walter Reed stands on the steps, while Dr. Jesse W. Lazear administers an inoculation. Dr. Carlos Finlay is the civilian at the left.

Reed was born Sept. 13, 1851, in Belroi, Va. His father, a Methodist minister, gave him good training in the classics and mathematics even during the tumultous Civil War years. When Walter was 15, his family moved to Charlottesville, Va. The next year he entered the University of Virginia. He specialized in medical studies in his second term and received an M. D. degree before he was 18.

In 1869 the tall, serious boy enrolled in the Bellevue Hospital Medical College in New York City for more study. He won a second M. D. degree in 1870. After internship, he worked for the New York City and Brooklyn boards of health. When he was 24 he entered the Army Medical Corps as a first lieutenant. A year of duty in New York was followed by 11 years at various army posts in the West. In 1876 he married Emilie Lawrence; they had two children.

Reed developed a keen interest in the new science of bacteriology. In 1890 he was transferred to duty in Baltimore and permitted to study at Johns Hopkins Hospital. After three years he was appointed professor of bacteriology and clinical microscopy at the Army Medical School in Washington, D. C.

At the outbreak of the Spanish-American War Reed headed a committee to investigate epidemics of typhoid fever raging through army camps. The committee found that flies and dust were helping to spread the disease. Reed recommended sanitation measures that reduced the disease rate. His work led to his appointment in 1900 as head of the Yellow Fever Commission, organized to combat the disease among troops stationed in Havana, Cuba.

Reed realized that the pressing need was to find out how yellow fever was being spread. He and his colleagues suspected that mosquitoes, not contact with fever victims or their clothing or bedding, transmitted the disease. In a series of controlled experiments they proved their theory. At once strict mosquito control measures were enforced, and yellow fever epidemics ceased. (*See also* Mosquito.)

In 1901 Reed returned to Washington and received many awards. But a neglected chronic appendicitis caused his death less than two years later on Nov. 22, 1902. The Army's great medical center in Washington, D.C., is named for him.

REED INSTRUMENTS. Among the most pleasing of musical instruments are those that use a reed as the sound-producing, or "speaking," part. These instruments include many of the wood winds as well as the harmonica, piano accordion, concertina, reed organ, and bagpipe (*see* Wood-Wind Instruments).

The reed itself is made either of metal or of a plant substance. The giant reed, or plume grass, *Arundo donax*, yields musical reeds. It grows to a height of 18 feet and is found both in the United States and in southern Europe. Metal reeds are made of brass, German silver, or steel.

One type of reed is the *free* reed. It vibrates from side to side in the enclosing air slot. A *beating* reed vibrates against the opening of the air slot itself, alternately cutting off and releasing the air flow. Beating reeds are either single or double. Single reeds work directly against the air slot. Double reeds are made of two segments joined in tube form at one end and in flattened form at the other.

The various clarinets have single beating reeds. They vibrate against slots in the mouthpieces. Members of the oboe family have double reeds. The two halves of the reed itself make up the mouthpiece. They vibrate against each other and so are classed as beating reeds. The bagpipe usually has a double reed in the chanter, on which the melody is played, and single reeds in the drones, which sound the continuous background tones (*see* Bagpipe).

Members of the reed organ family (harmonica, accordion, concertina, and others) have a separate free reed for each note. The saxophone, usually classed as a brass instrument, has a single reed mouthpiece and a brass body. It might well be classed as a reed wood wind.

The reference desk in the Newark (N.J.) Public Library is a busy spot. One librarian has reached for a magnifying glass to help him answer a detailed map question. The other has used one of the volumes behind her to answer her telephone inquiry.

REFERENCE BOOKS—

Keys to Knowledge

REFERENCE BOOKS. Everyone asks questions and everyone likes to get the right answers. A quick way to get an answer is to turn to some person who knows the subject. A more certain way is to turn to books.

Books always have been and continue to be treasure houses of answers. Both fact and fiction books teach us things we have never known about people, places, and things. In this sense all books answer questions for us. The Reference Department of the New York Public Library regards all books in just this way. More than 3 million books are held there for use only in the building. With the help of the staff, people from all over the world use the collection. There, daily, hundreds of people find the answers they want, proving that the library deserves its nickname, The House of Answers.

Even though all books are in a sense answer books, some are written especially to answer questions. Such books are called reference books. Learning how to use them is an important part of education.

Some people specialize in this skill and after years of training spend their lives working as reference librarians. Many people assume that a reference librarian knows all the answers. He does not; but he does know where he will find the right answer. Questions reach the reference desk directly from people visiting the library, by telephone from homes and offices, and by mail. The librarian does his best to answer all questions correctly and quickly.

Few people need to know as much about reference books as a librarian. With some study and browsing anyone can learn how to use many of these books. Knowing where to look for the books and how to use them will usually lead to the right answer.

Kinds of Reference Books

Most librarians agree that about 10,000 different books are regularly used for reference purposes. Many of these fall into groups. A simple grouping is: Encyclopedias; Dictionaries; Atlases and Gazetteers; Indexes; Handbooks and Manuals; Biographical Directories; Bibliographies; and Almanacs and Miscellany. A home library should have at least one title in each of the first four groups. Many good books in all these classes are in all public libraries.

When one knows examples in each group, he has a key to the answers of many of the world's questions. Whether the questions spring from schoolwork or dinner-table arguments, from television quiz programs or just plain curiosity, answers can be found.

Judging Reference Books

All good reference books have something in common. They are accurate. If a reference book gives the wrong answer frequently, it does not deserve to be called a reference book. The best reference books

are those which give adequate, up-to-date information written in plain language without editorial opinion. *Authority* and *fairness* are two other important elements that are common to good reference books.

One point that has to be known in relation to all reference books is their *scope*. No book attempts to answer all questions. The good reference publisher indicates the scope of his publication. The publication should be judged adequate if it furnishes the information that should be found within those limits. The reader should not expect to find information in the field of mythology in a chemistry handbook. He should, however, expect to find the answers to chemical questions in that handbook.

Other important elements in reference books are *arrangement* and *readability*. The reader using a reference book expects to find a fact quickly. Well-arranged books let him do just that. Arrangement varies with the type of book. Dictionaries and encyclopedias are usually arranged alphabetically; atlases and gazetteers, by continent and country divisions. Statistical handbooks usually divide the tables by broad subjects and supplement them with an alphabetical index. Whatever the arrangement, it is good if it is simple, consistent, and easily understood.

It is equally important that the facts themselves be easily understood. No matter how much authority has gone into the preparation of a reference book, it is of little value if the material is not readable. The best reference works are carefully edited for both accuracy and ease of reading.

The well-made, attractive book is a pleasant book to use, and the elements of *design* and *format* are important in judging reference books. Illustrations are being used more and more to help explain the printed text. Pictures in black and white or in color, carefully selected and placed, add to the understanding of facts. At the right point in the text, a chart, diagram, or picture may save paragraphs of technical explanation. Words about distant places, discoveries, and processes many times come to life only when they are identified through clear maps, diagrams, or pictures. This wide variety of illustration, plus well-chosen and well-spaced type, good quality paper, and sturdy binding, contributes to the attractiveness and usefulness of the book.

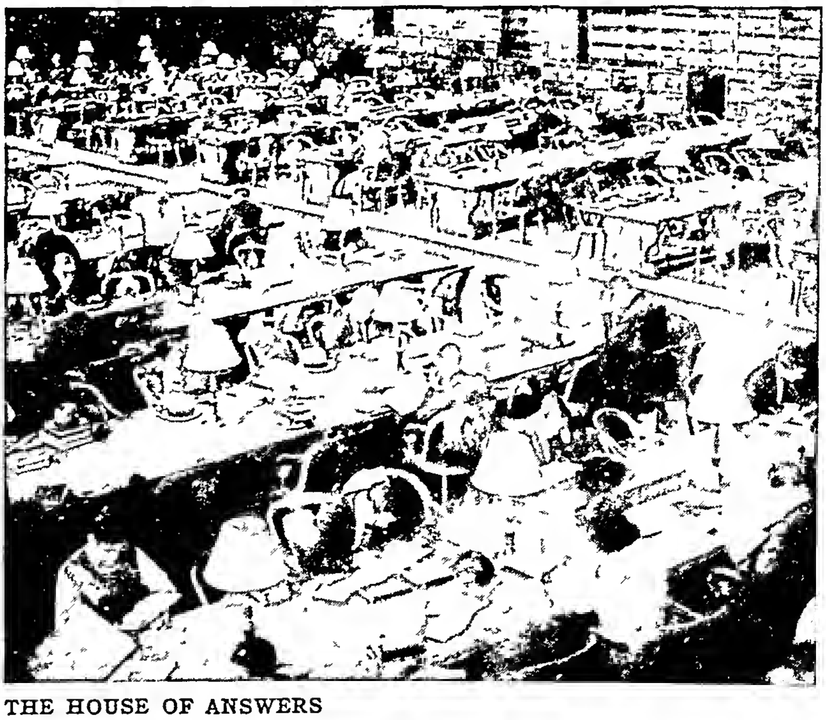
Bibliographies in a reference book are of double importance. Primarily, these lists of source material indicate where the editors have found the facts which have gone into the book. In addition, they give tips to the interested reader as to where he can find more information. No reference book can be so adequate that it gives all the information every reader may want. As a result these reading lists are valuable in guiding the reader to that additional information.

ENCYCLOPEDIAS

Many people think of encyclopedias as the only reference books. To a degree this is correct because as a group encyclopedias are the most important reference tools. No library can get along without recent editions of the better sets. Families that own an encyclopedia find that most of their questions are answered from that single source.

By its definition an encyclopedia includes in a single publication knowledge of importance to man in many different fields. In the best encyclopedias this information is presented in articles of various lengths, arranged alphabetically by subject and supplemented with a careful, detailed index. Because of the range of man's knowledge today the great encyclopedias extend to many volumes. There have been a few attempts to present one-volume encyclopedias but these have proved of limited use.

The preparation of a good encyclopedia involves years of hard work on the part of hundreds of people. Scholars in a wide variety of subject fields prepare the original articles. Editors rework those articles to fit the style and pattern of the encyclopedia. Librarians and research workers recheck the accuracy of the facts. Artists and typographers work closely with the material to determine the final design of the volumes. Indexers comb the articles for major subject material and significant small facts. These are then pointed out for the benefit



THE HOUSE OF ANSWERS

This is less than one half the area of the main reading room of the New York Public Library. Here daily, hundreds of readers hunt for their answers.

of future readers through short entries in the alphabetical index.

If throughout this labor of preparation the highest standards have been maintained, the publication deserves the title of "encyclopedia." Even after publication the publisher's responsibility continues. In successive printings, new facts, ideas, and theories deserve places in the set. To keep the encyclopedia up to date the best publishers have arrived at the practice of continuous revision. This means constant rewriting and reillustration of articles to record fresh knowledge. Comparison of two editions of the same encyclopedia easily shows how carefully such a revision program has been followed.

Learning to Use an Encyclopedia

Even when encyclopedias contain many of the wanted answers, those answers are most available to people who have learned how to use the books properly. The best way to learn how to use an encyclopedia, and a good way to judge the quality of it, is simply to practice with it. Select an interesting broad subject. With the aid of the index and cross-references, track down all the information in the encyclopedia related to that subject.

If the search proves to be an easy and productive one, the encyclopedia can be regarded as a good reference work. If in such a search the reader fails to find all the information easily or runs into blind alleys, the value of the encyclopedia is lessened.

Encyclopedia indexes vary; some are in a single volume, while others are a part of each volume of the set. Good indexes carefully collect all references in the set under subject headings, with simple directions to volume and page numbers.

The style of cross-references in encyclopedias also varies. One kind, a "see" reference, directs the reader to that point in the set where he can find the information he wants (Physiography, *see* Physical Geography). The other kind, a "see also" reference, directs the reader to related material in the set (Physical Geography, *see also* Earth; Glaciers; Volcanoes).

In practicing with any encyclopedia these variations become familiar. At the end of the search the mechanics of the set are learned, and it will be easier to use that encyclopedia the next time.

History of Encyclopedias

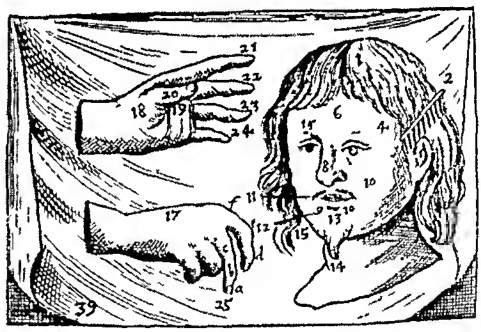
The idea of an encyclopedia dates from man's first thought about recording and passing on knowledge. The word itself comes from an ancient Greek word meaning the "whole circle of knowledge." The work generally considered as the first encyclopedia is Pliny's 'Natural History', compiled during the first century. In 37 volumes Pliny presented some 20,000 facts gathered from 2,000 books written by 100 authors.

The first English language encyclopedia was published in 1481 by the famous printer William Caxton. It was a translation from the French and appeared in English as 'Myrrour of the World'. Credit for first using the word encyclopedia as a title goes to Johann Heinrich Alsted, a German, for his work under that name published in 1630.

The first alphabetically arranged reference work in English was written by John Harris. It was published in 1704 under the title 'Universal English Dictionary of Arts and Sciences'. Inspired by this work, Ephraim Chambers published in 1728 his 'Cyclopaedia or an Universal Dictionary of Arts and Sciences'. This publication is historically important for three reasons: it was the first to emphasize the use of many authorities as contributors; it introduced cross-references; and, most important of all, it served as the inspiration for the great French 'Encyclopédie'.

French and British National Encyclopedias

John Mills, the English political scientist, started the translation of the Chambers' encyclopedia into French. After an argument with the publisher, he withdrew from the project and the work was turned over to Diderot. Under Diderot's direction, such men as Voltaire, Rousseau, d'Alembert, and Montesquieu contributed to the 'Encyclopédie'. This 28-volume set and supplements were published from 1772 to 1780. The revolutionary spirit of the period was reflected in many of the articles. Judged by modern



Caput & Manus. The Head and the Hands.

In the Head are,	In Capite ſunt
The Hair, 1.	*Capillus,* 1.
(which is combed	(qui pectitur
with a Comb, 2.)	*Pectine,* 2.)
two Ears, 3.	*Aures* 3. binæ.
The *Temples,* 4.	*Tempora,* 4.
and the face, 5.	& *Facies,* 5.
In the Face are,	In facie ſunt
the Forehead, 6.	*Frons,* 6.
both the Eyes, 7.	*Oculus* 7. uterq;
The Noſe, 8.	*Naſus* 8.
(with two Noſtrils)	(cum duabus *Naribus*)
The Mouth, 9.	*Os,* 9.

Gena

THE FIRST ILLUSTRATED CHILDREN'S BOOK
'Orbis Pictus', published in 1657, proved the value of printed illustrations in teaching. English words, Latin words, and crude diagrams recorded the known world of that time.

THE ENCYCLOPEDIA AT HOME
Two high-school students turn to the family encyclopedia to get help with their physics assignment—atomic energy.

standards of fairness and accuracy, the encyclopedia was not a good one. It was important, however, because of its influence, and it became recognized as the first great national encyclopedia.

The greatest national encyclopedia and the one with the longest publishing history, 'Encyclopaedia Britannica', started publication in December 1768. With its ninth edition, completed in 1889, encyclopedia making reached a new peak in scholarship. The quality of this edition led to world recognition of "Britannica." Edited and published in the United States since 1920, this encyclopedia has in recent printings been to a degree Americanized. It is no longer considered by the British to be their national encyclopedia.

America's Contribution to Encyclopedias

The American encyclopedia with the longest continuous publishing record is 'The Encyclopedia Americana', which dates from 1829. The most recent of the good American adult sets is 'Collier's Encyclopedia', first published in 1949.

Notable American contributions to encyclopedias have been made in the school and young people's field. John Newbery's 'Circle of the Sciences' (London, 1745), may be regarded as the first attempt to publish a children's encyclopedia, but it is in the United States that such encyclopedias have been developed. One of the earliest was the two-volume 'Student's Cyclopedia', first published in 1893. In 1912 it was purchased by Frank E. Compton. The need for and success of that publication led to the planning and publication of 'Compton's Pictured Encyclopedia'. First issued in 1922, it has been continuously revised with a new edition each year since that date.

Compton's has made many contributions to good encyclopedia practices. Probably the most important of these is the emphasis on illustrations. Although pictures had been used even as far back as 'Orbis Pictus', published in 1657, no encyclopedia has ever before included so many and such a variety of illustrations. Beginning with the first edition in 1922, well-chosen illustrations, closely related to the text, have been a feature of Compton's.

A second major encyclopedia idea, the Fact-Index, also dates from the first edition. A new dimension was added to the old art of indexing by including in the index brief factual paragraphs as well as the more conventional index references to the text.

The third major contribution made by Compton's first appeared in the 1932 edition. Previous to that publication, encyclopedias had used the "split-letter" arrangement of volumes—A-ANA, ANA-BAD, and BAD-CAD—to indicate what articles could be found in each volume. The innovation was the "whole-letter" idea. To make the use of the encyclopedia much easier, all the articles beginning with a single letter, as well as the Fact-Index entries beginning with that letter, are collected in a single volume. The result is the now familiar pattern of the backs of the volumes—A, B, C, and DE.

SELECTED LIST OF AMERICAN ENCYCLOPEDIAS

School and Family Encyclopedias

Compton's Pictured Encyclopedia. Chicago. F. E. Compton & Company. 15 vols.

World Book Encyclopedia. Chicago. Field Enterprises, Inc. 19 vols.

Adult Encyclopedias

Collier's Encyclopedia. New York. P. F. Collier & Sons. 24 vols.

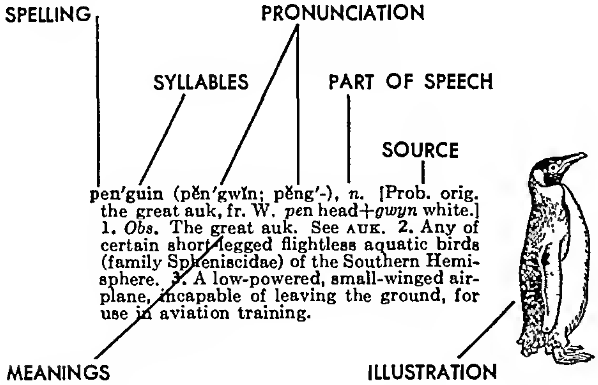
Encyclopaedia Britannica. Chicago. Encyclopaedia Britannica, Inc. 24 vols.

The Encyclopedia Americana. New York. Americana Corporation. 30 vols.

DICTIONARIES

Everyone uses dictionaries to check spellings, pronunciations, and meanings of unfamiliar words. But few people realize the wealth of information in this type of reference book. A dictionary can be defined as an alphabetically arranged list of words with meanings. Four kinds of dictionaries are found in libraries: English language; supplementary language; foreign language; and subject dictionaries. Of these four groups, a good example of at least the first should be in every home.

The earliest English dictionaries were compiled to explain difficult and foreign words. Easy words were not included because it was felt that everyone knew them. The first English dictionary, Robert



THE DICTIONARY'S PENGUIN

This entry from G. & C. Merriam's 'Webster's New Collegiate Dictionary' is diagramed to show all its information.

Cawdrey's 'A Table Alphabeticall', 1604, was little more than a list of words in Latin and French texts.

As dictionaries developed the easy words were included with the hard ones. Even then no attempt was made to include all the words in the English language. Nathan Bailey, who gave the English people 'An Universal Etymological English Dictionary', in 1721, made it clear that he had included only those words in good standing. When Dr. Samuel Johnson was asked to prepare an English dictionary he readily accepted, pleased to be able to serve as a literary dictator in choosing the proper words.

Johnson's great 'Dictionary, with a Grammar and History of the English Language' appeared in 1755 and was reprinted countless times in the following century. It can be found in most large libraries today in one edition or another but is regarded as a literary curiosity. Many of Johnson's definitions were too complicated. For example, he defined "network," as "anything reticulated or decussated at equal distances, with interstices between the intersections." Many definitions included the author's personal opinions (*see* Johnson, Samuel). Even with these faults, when his dictionary first appeared it was a landmark in dictionary making.

The first great American dictionary was produced by Noah Webster in 1828. Titled 'An American Dictionary of the English Language', it included about 70,000 words and emphasized differences in meanings and usage between the United States and England. This volume too included only words in good standing. Since the publication of Webster's first dictionary, his name has been linked with American dictionary making. There are many modern dictionaries that use the Webster name, but those that are closest to his spirit of scholarship are known as Merriam-Webster dictionaries (*see* Webster, Noah).

Today's concept of a dictionary was the result of a scholarly paper read to the members of the Philological Society in London. It was in 1857 that Richard Trench, Dean of Westminster, appeared before that group to report his thinking "On some Deficiencies in our English Dictionaries." His main point was that "it is no task of the maker of it to select the *good* words of the language." He went on to explain the true job of the dictionary maker, the recording of all words used by the people.

It was this idea that led directly to the greatest of all English dictionaries, 'A New English Dictionary on Historical Principles'. Publication in parts began in 1884, and the final part did not appear until 1928. Ten years after publication started, 'The Oxford English Dictionary' was added to the original name. This tremendous project, which set out to record all words in the English language and how they are and have been used, involved 70 years of research. A thousand British and American scholars collected 5,000,000 quotations from 5,000 writers.

Because language is a living and changing thing, the "O. E. D." cannot be considered the final perfect dictionary. It will, however, be permanently valuable as a scholarly historical record of the English language. It also has helped fix forever the idea that dictionaries must be based on usage.

Dictionaries Today

Good dictionaries are available today at all reading levels. Some of the simplest ones have been prepared for the early elementary grades in school. The largest ones are the unabridged works which are usually found in libraries and are constantly consulted because of their authority in relation to correct word usage. A selection of the best modern dictionaries is presented at the end of this section.

The shorter, or desk, dictionaries today are not limited by the old idea of including only the "hard" or "good" words. They are constructed on the scientific basis of frequency of usage. This idea, promoted in the word list studies of Dr. Edward L. Thorndike, is based on actually counting how often words are used in everyday writing. Those words used most often are included in the desk dictionaries. Only the unabridged dictionaries are compiled without considering frequency of usage, but even these do not include many technical and obsolete words.

The standard unabridged dictionaries include roughly 400,000 words. Desk dictionaries seldom include more than about 125,000 words.

All these dictionaries supply a great deal of information about each word. The word itself is correctly spelled, divided into syllables, and marked to show an acceptable pronunciation. The source of the word is indicated and its part of speech identified. Several meanings of the word are listed in the order of usage. Synonyms and antonyms are often supplied, and many of the words are illustrated by drawings.

Smaller than the two kinds of dictionaries already described are the high-school dictionaries. These usually include 45,000 to 70,000 of the more common words. Next are the intermediate dictionaries, which may include 30,000 to 40,000 of the most commonly used words. At the most elementary level is the primary dictionary, with fewer than 5,000 words. In these the words are explained through pictures or through use in simple sentences.

The Thesaurus and Other Dictionaries

The dictionaries known as supplementary language dictionaries serve different functions. They deal with special phases of language. A good example is a usage book, P. G. Perrin's 'Writer's Guide and Index to English'. It answers questions about punctuation, spelling, paragraphs, sentences, and grammar—answers not usually found in the ordinary dictionary. Another important supplementary language book is the handbook of synonyms. It gives shades of differences in meaning among words which mean approximately the same thing. The most famous is P. M. Roget's 'Thesaurus', which is arranged by ideas. The use of this kind of book can add color to writing and helps to avoid monotony in word choice.

Still other language reference books are devoted to abbreviations, rhymes, slang, and technical and foreign terms. Any good library collection includes these and many others, compiled to help answer whatever language questions may be asked.

In every foreign language there is a wide variety of dictionaries, but the ones that are the most helpful to English-speaking people are those which are bilingual. These are constructed not to give the meaning of words but to give the foreign language equivalent of the English word. Most of these dictionaries are devoted to a single foreign language.

SELECTED LIST OF MODERN DICTIONARIES

Unabridged (400,000 words)

Funk and Wagnalls New Standard Dictionary of the English Language. New York. Funk & Wagnalls Co.
Oxford English Dictionary. Oxford. Clarendon Press.
Webster's New International Dictionary. Springfield, Mass G. & C. Merriam Co.

College or Desk (125,000 words)

American College Dictionary. New York. Random House.
Funk and Wagnalls New College Standard Dictionary. New York. Funk & Wagnalls Co.
Webster's New Collegiate Dictionary. Springfield, Mass. G. & C. Merriam Co.
Winston Dictionary. Philadelphia. John C. Winston Co.

High School (45,000 words)

New Winston Dictionary for Young People. Philadelphia. John C. Winston Co.
Thorndike-Barnhart High School Dictionary. Chicago. Scott, Foresman and Co.
Webster's Students' Dictionary. Cincinnati. American Book Co.

Intermediate (30,000 words)

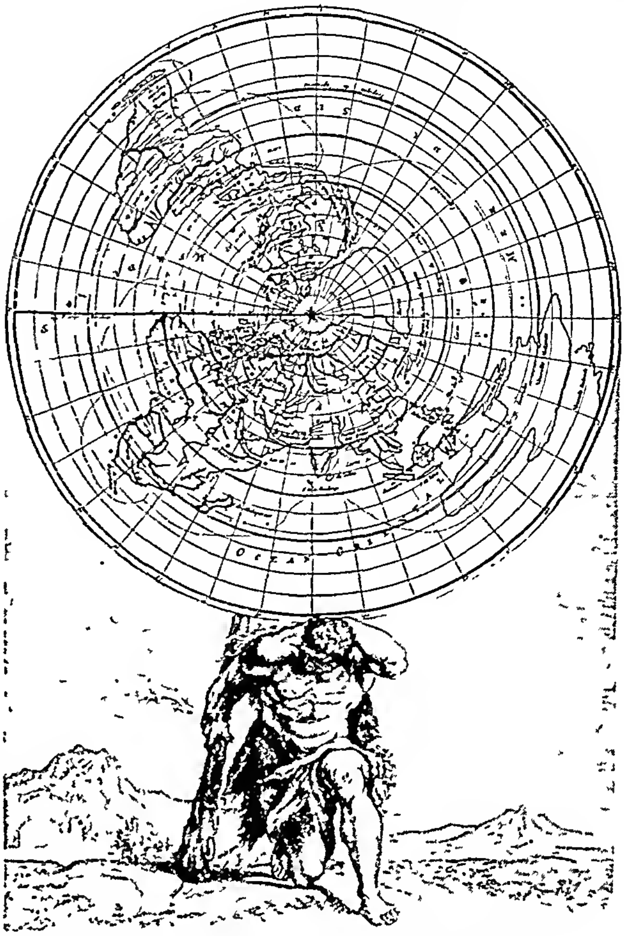
Thorndike-Barnhart Junior Dictionary. Chicago. Scott, Foresman and Co.
Webster's Elementary Dictionary. Cincinnati. American Book Co.
Winston Dictionary for Children. Philadelphia. John C. Winston Co.

Primary (fewer than 5,000 words)

Golden Dictionary. New York. Simon & Schuster.
My First Dictionary. New York. Grosset & Dunlap.
Rainbow Dictionary. Cleveland. World Publishing Co.

ATLASES AND GAZETTEERS

By definition an atlas is a collection of maps published in one volume. The atlas group includes the widest variety of publications. An atlas in its simplest form may be pocket size, providing road or street directions. In its most elaborate form an atlas is large enough to need a reading stand to support it. The wealth of maps in the large atlases presents the known geographic facts of the current world.



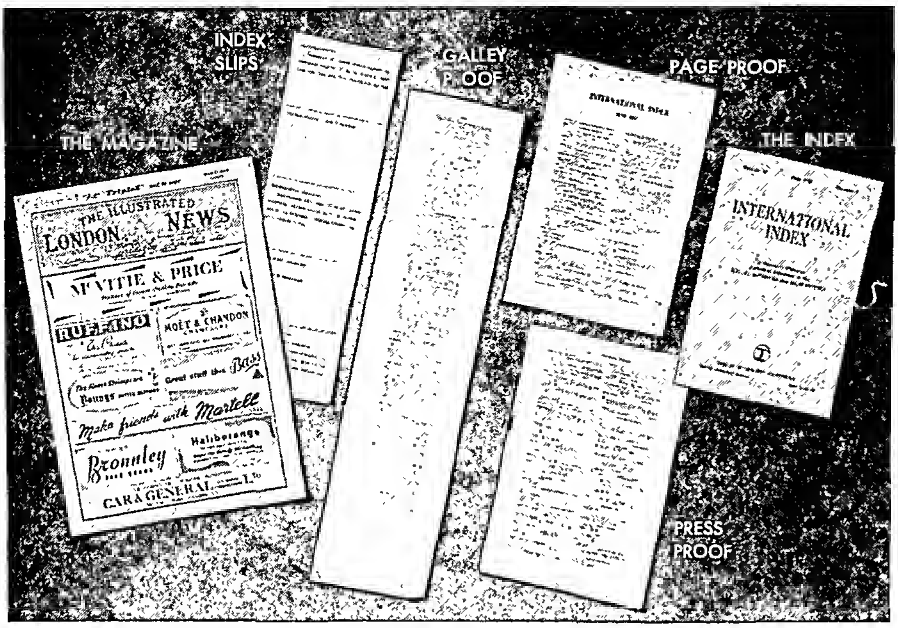
ATLAS AS HE APPEARED IN A 1715 ATLAS
Reynard of Amsterdam used this drawing of Atlas in his map collection. The map itself is older. It is Cassini's polar projection, today's air-age map, first printed in 1696.

The word "atlas" to describe a collection of maps originated when one of the early collections included as decoration for the maps the figure of the giant Atlas supporting the world on his shoulders. Probably it was the Flemish geographer, Gerhardus Mercator, who first used the word for a collection of maps he began in 1585 and his son completed in 1594.

Good atlases usually include one hundred or more individual maps. These are usually presented in geographic sequence, with maps covering the whole world first, followed by maps arranged by continent, country, region, and smaller areas. A gazetteer index is frequently added to the atlas. This helps to locate places on the maps quickly, gives populations, and provides information about points of interest.

How to Locate Places in an Atlas

Knowledge of the arrangement of an individual atlas is necessary before it can be used successfully. The most important information is the sequence in



THE WILSON COMPANY INDEX SYSTEM

The index process starts with the magazine, from which index slips are made, continues through several proof stages, and finally reaches the form of an issue of the Index. A foreign magazine indexed for the "International Index" is used here to illustrate the process. Exactly the same process is followed in the indexing of the several hundreds of magazines that are included in the numerous Wilson publications.

which the maps themselves appear. The second major fact in relation to the atlas is the arrangement of the index information. In some atlases the index to places is printed on the back of the maps themselves. In others, all the place names are collected in an alphabetical list in an index section of the volume.

Whatever index system is used, the place names will be followed by one of two finding devices. The traditional system locates a place by giving its exact longitude and latitude. A second and equally popular method involves numbered and lettered sections separated by grid lines on the map. The index locates points by naming the area with a number and a letter.

A third important element in the intelligent use of any atlas involves knowing the kind of map projection used in the atlas. Since the earth's round surface has to be represented on a flat page the presentation is always distorted. In the history of map making many different kinds of projection have been developed (*see* Maps). Any one or a combination of these may be used in a modern atlas. It is of major importance to know which one is being used and to understand the resulting distortion.

It is possible to find in a large reference library atlas material to help in almost any study. Atlases, like dictionaries, are published in a wide variety. Simple ones are available for use in elementary schoolwork. At the other extreme, highly complex atlases are available for the use of the scientific geographers of the world. There are also many special types of atlases. In this group are atlases concerned with such subjects as weather conditions, animal distribution, location of mineral deposits, population centers, and the geography of the Bible.

Gazetteers are probably best described as geographic encyclopedias. They seldom include much in the way of actual map material. Through brief, factual description of places and through the use of pictorial material they record a wealth of geographic information. The use of a good gazetteer, together with a good modern atlas, brings reality to current world news. By locating strange place names and learning the facts about these places the newspaper reports from around the world can be better understood.

SELECTED LIST OF ATLASES AND GAZETTEERS

Atlases

Goode's World Atlas. Chicago. Rand McNally & Company.
Hammond's Complete World Atlas. Maplewood, N. J. C. S. Hammond and Company.
Rand McNally Cosmopolitan World Atlas. Chicago. Rand McNally & Company.

Gazetteers

Columbia Lippincott Gazetteer of the World. New York. Columbia University Press.
Webster's Geographical Dictionary. Springfield, Mass. G. & C. Merriam Co.

INDEXES

UNESCO has defined an index as a "systematically arranged list giving enough information about each item to enable it to be identified and traced." Without the wealth of index material available today, no reference librarian could do his job. Much of this material comes from a single company, the H. W. Wilson Company, which during this century has developed the art of indexing to its highest level.

All their numerous indexes are published in parts, by a definite schedule through the year. All of them also use a system of cumulation (gathering) which helps the reader locate all current information with the least possible effort. The best known of the Wilson indexes, 'Readers' Guide to Periodical Literature', provides a graphic example of this technique. This serves as a subject guide to articles in more than one hundred of the most popular American magazines. Less than a month after the appearance of the magazines, all the subject articles have been analyzed and recorded in an issue of the index.

These articles are described in a brief but complete entry similar to the following:

> MOTOR truck driving
> He rolls the big trucks. W. Favel. il Scholastic 66·21 Ap 13 '55

This entry is easy to translate. It indicates that an article by W. Favel about trucking, with illustrations, appeared in *Scholastic*, volume 66, page 21, of the April 13, 1955, issue.

That same entry is reprinted through a sequence of unbound issues of the Guide, cumulated with other references to articles about trucking. At the end of two years the total list is printed in a permanent volume. This includes all the index references to the magazines for that period.

Another valuable Wilson index compiled in the same fashion is the 'Essay and General Literature Index', a subject guide to material which has appeared in books rather than in magazines. Other indexes from this company are concerned with special subject fields: agriculture, art, book reviews, and education. Once the process of using the basic index is learned, these special indexes, built in the same fashion, help locate material in hundreds of periodicals in special rather than popular fields.

The American Library Association has made a contribution to the field of indexing. One of its notable series, the subject indexes to books, is compiled by Eloise Rue. Other professional organizations publish indexes and abstracts in their own fields.

HANDBOOKS AND MANUALS

This classification of reference books is probably the most difficult to explain because the books in it have so little in common. They, however, have all been written or compiled to furnish information about a special subject quickly. That subject may be baby care, etiquette, or how to build a boat in the basement. In each of these fields and in hundreds of others there are books which help.

Learning to use these books depends upon two of the elements that are important in relation to encyclopedias. The first is the scope of the volume, and the second is the arrangement. A study of the introduction and index of any good handbook or manual is all that is necessary to gain the key to its easy use.

The hundreds of books in this group cannot all be listed. Discussion of a few of them will indicate how valuable they are in finding the right answer.

Finding Quotations, Facts, and Statistics

"Who said that?" is a question that is constantly asked, and a large group of quotation books provides the answers. The best of them are miracles of organization, constructed so that whatever the approach may be—author, subject, or quotation—the answer is easy to find. Whether it is a "rose is a rose is a rose" or a "rose by any other name," the author's name and the exact quotation can be found.

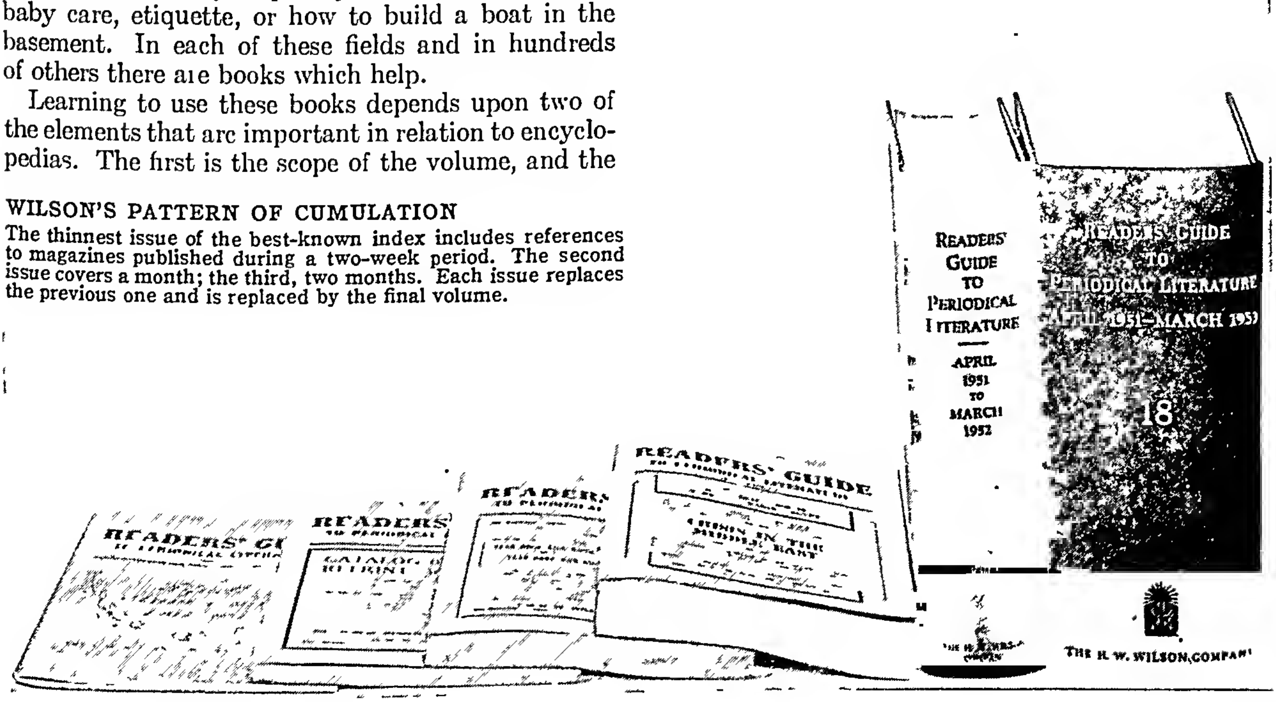
"What happened when?" is another persistent kind of question, and a different group of books provides the answers. One of the most interesting is J. N. Kane's 'Famous First Facts', "a record of first happenings, discoveries and inventions in the United States." Another is G. W. Douglas' 'American Book of Days', which records day-by-day major holidays, local history, and birthdays of important people.

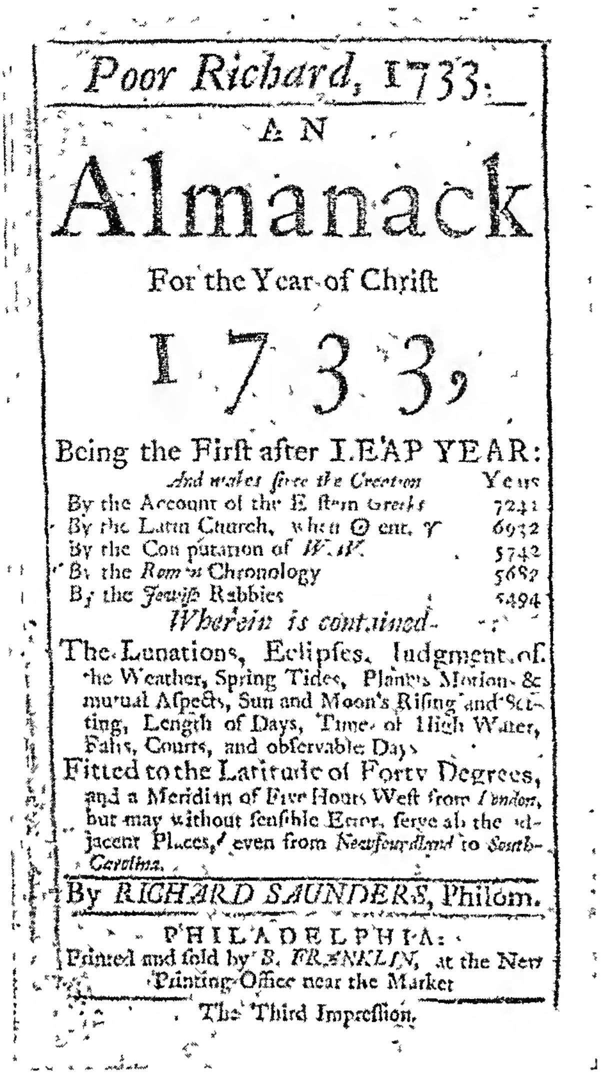
"How many —?" is also a question that is frequently asked. Another large group of books helps answer these queries. One of the most valuable is a publication of the United States government, the 'Statistical Abstract'. This is issued each year and provides more "how many" answers than any other single publication. Census publications and other government documents help answer other questions in this field.

"How do I do this?" is a question which arises in the minds of people constantly. The question is asked so often that thousands of books have been compiled

WILSON'S PATTERN OF CUMULATION

The thinnest issue of the best-known index includes references to magazines published during a two-week period. The second issue covers a month; the third, two months. Each issue replaces the previous one and is replaced by the final volume.




Poor Richard, 1733.

AN

Almanack

For the Year of Christ

1733,

Being the First after LEAP YEAR:

And makes since the Creation — Years
By the Account of the Eastern Greeks — 7241
By the Latin Church, when ☉ ent. ♈ — 6932
By the Computation of W. W. — 5742
By the Roman Chronology — 5682
By the Jewish Rabbies — 5494

Wherein is contained

The Lunations, Eclipses, Judgment of the Weather, Spring Tides, Planets Motions & mutual Aspects, Sun and Moon's Rising and Setting, Length of Days, Time of High Water, Fairs, Courts, and observable Days

Fitted to the Latitude of Forty Degrees, and a Meridian of Five Hours West from London, but may without sensible Error, serve all the adjacent Places, even from Newfoundland to South-Carolina.

By RICHARD SAUNDERS, Philom.

PHILADELPHIA:
Printed and sold by B. FRANKLIN, at the New Printing-Office near the Market

The Third Impression.

BENJAMIN FRANKLIN'S REFERENCE BOOK

The title page of the first issue of this early American almanac records in detail the contents of the volume. It fails to show that the almanacs also included much of Franklin's wit.

to answer it. The "how" may be concerned with anything from how to run a club meeting to how to know which fork to use for salad. On the other hand, it may be concerned with how to protect yourself while raising bees for profit or how to administer artificial respiration. Whatever the question there is a book with the answer. Today the literature in this field is so extensive that one bibliography, Robert Kingery's 'How-to-do-it Book', devotes almost three hundred pages to listing and describing the books in this category.

Some of the more popular handbooks are listed in the following bibliography. These and other titles in the library will answer the questions so well expressed by Rudyard Kipling in his:

> I keep six honest serving-men
> (They taught me all I knew);
> Their names are What and Why and When
> And How and Where and Who.

SELECTED LIST OF HANDBOOKS AND MANUALS

American Red Cross. First Aid Textbook. New York. Blakiston Company, Inc.

Bartlett, John. Familiar Quotations. Boston. Little, Brown & Co.

Benet, W. R. Reader's Encyclopedia. New York. Thomas Y. Crowell Company.

Douglas, G. W. The American Book of Days. New York. H. W. Wilson Company.

Economic Almanac. New York. Thomas Y. Crowell Company.

Kane, J. N. Famous First Facts. New York. H. W. Wilson Company.

Post, Emily. Etiquette. New York. Funk & Wagnalls Co

Robert, H. M. Rules of Order. Chicago. Scott, Foresman & Company.

Stevenson, B. E. Home Book of Quotations. New York. Dodd, Mead & Co.

United States. Bureau of the Census. Statistical Abstract. Washington. Government Printing Office.

United States. Children's Bureau. Infant Care. Washington. Government Printing Office.

BIOGRAPHICAL DIRECTORIES

One of the largest groups of reference questions is about people, and a whole library of biographical directories has been compiled to answer those questions. On the simplest level, a telephone book can be considered as a biographical directory. At the other extreme lie the extensive biographical reports, complete with pictures and short lists of references, that are found in 'Current Biography'.

The question of scope is again the most important element in learning to use this collection of books efficiently. Some of the publications attempt to give facts in relation to all notable people of all times. Others are concerned with only the important, already dead, personalities of a single country. Still others attempt to list all people of importance in relation to a single subject specialty.

SELECTED LIST OF BIOGRAPHICAL DIRECTORIES

American Men of Science. New York. R. R. Bowker Co. (Short biographies of American living scientists, an example of the special subject directory.)

Current Biography. New York. H. W. Wilson Co. (Detailed biographical information concerning living international celebrities.)

Dictionary of American Biography. New York. Scribner's Sons (Extensive selection of famous American dead.)

Dictionary of National Biography. Oxford. Oxford University Press. (Extensive selection of famous British dead.)

New Century Cyclopedia of Names. New York. Appleton-Century-Crofts, Inc. (Notable people of international importance, living and dead.)

Webster's Biographical Dictionary. Springfield, Mass G. & C. Merriam Co. (Notable people of international importance, living and dead.)

Who's Who. London. A. & C. Black. (Capsule biographies of important living British citizens.)

Who's Who in America. Chicago. A. N. Marquis Co. (Capsule biographies of important living Americans.)

BIBLIOGRAPHIES

Bibliographies are closely related to indexes in as much as they too serve as finding lists. The chief differences lie in the fact that they are frequently more specialized in their scope and are selective to the point of identifying the best available material. A bibliography can be as brief as the

book lists included in this article or extensive enough to be published in several volumes. Every reader, whether his interest is casual or scholarly, can extend his knowledge through the use of the thousands of available bibliographic sources. (*See also* Bibliography.)

ALMANACS AND MISCELLANY

No discussion of reference sources can be complete without this kind of grouping of a few major titles which defy easy classification. Almanacs, wonderful catchalls of miscellaneous information, clearly cannot be classified. They are among the oldest types of reference books and originally were simple calendars with notes about principal holidays, weather predictions, and astronomical observations.

The most famous of the early American almanacs was 'Poor Richard's Almanack'. The literary product of Benjamin Franklin during the period 1732–57, it was continued by others until 1796 (*see* Franklin). The oldest continuous publication in this field first appeared in 1792 as 'The Farmer's Almanack . . . for the Year of Our Lord 1793'. Today the direct descendant of that publication, 'The Old Farmer's Almanack', can be found hanging on a nail in many rural kitchens. In its slim pamphlet appearance and with its concern with year-round weather predictions, the "Farmer's Almanack" today would not look too strange to those people who used the first edition of it over 150 years ago.

The two popular modern American almanacs are 'The World Almanac', published annually by *New York World-Telegram and The Sun* since 1868, and 'Information Please Almanac', the product of the quiz program of the same name, published annually since 1947. Both of them include such diverse information as political history and baseball batting averages. Both are well indexed. In the process of learning how to find the answers to reference questions it is frequently wise to check these volumes before turning to more specialized sources.

DOCUMENTS CONTRIBUTE TO REFERENCE WORK
The extensive publishing program of the United States government provides thousands of reference sources. Here, being checked in at the Free Library of Philadelphia, is a single day's mail from the Government Printing Office.

A reference book which cannot be overlooked is the "book of books"—the Holy Bible. It is not only the book referred to most often, but it is the source of numerous other reference books that refer to it. The Bible is so important it is not surprising that there are in existence examples of every variety of reference book based on its subject matter. The complete Bible library includes the various authorized versions of the Bible as well as encyclopedias, dictionaries, atlases, handbooks, directories, indexes, concordances, and bibliographies concerned only with Bible lore (*see* Bible).

The most specialized of all reference books are books about reference books. Through the use of three basic publications of the American Library Association—Constance M. Winchell's 'Guide to Reference Books', Louis Shores's 'Basic Reference Sources', and the quarterly publication 'Subscription Books Bulletin'—the reference works of the world can be located. Fom those reference works, large and small, most of the questions of the world can be answered.

REFLEXES. Accidentally touch a hot stove, and you jerk your hand away before you are badly burned. If you had to think before acting, you might be more severely hurt. This ability to act quickly and without conscious thought is called a reflex. Reflexes actually help guide most of the body's work, even when we are asleep.

One important task of the reflexes is to help the body adjust to changes. For example, as the day changes to twilight the pupils of our eyes automatically grow larger to aid vision in the dimmer light. If we switch on a lamp, the pupils contract to avoid damage to the sensitive retina. This is a reflex reaction involving only certain muscles.

Reflexes can also help to control action of the glands. Food on the tongue stimulates the salivary glands, and the mouth "waters." When we are angry or afraid, a set of glands called the adrenals react by sending a chemical called adrenalin coursing through the blood. The adrenalin stimulates the body mechanisms and helps us take emergency action. (*See also* Hormone.)

Such chains of swift action work through patterns of nerves called *reflex arcs.* In its simplest form the nerve pattern begins with a tiny *receptor* on the surface of or inside the body. Each receptor responds to one kind of sense impression, such as heat or cold, pressure, or sound. It sends its responsive message, or impulse, through nerve fibers to a motor cell. This cell, in turn, sends an impulse to a muscle or gland, which responds to the original sense impression by some action. Sometimes the reflex arc is routed through connections in the spinal cord or lower part of the brain. Other simple arcs may pass directly from the receptor to the motor cell. (*See also* Nerves.)

A simple example of a reflex reaction is the "knee jerk," used by doctors to test the soundness of nerves. The doctor instructs his patient to cross his knees and let his free leg hang relaxedly. Then he sharply taps a point just below the kneecap. If the patient's nerves are sound, he responds with a sudden and uncontrollable kick.

Few reactions, however, arise from a single sense impression. A burned finger, for example, immediately sends impulses of heat, pain, and perhaps pressure. Thus jerking the hand away is the result of a complex structure of reflex arcs, involving even such glandular action as the release of adrenalin.

Reflexes in Animals and Man

Every animal that has a nervous system also has reflex reactions. Even one-celled creatures (protozoa) make reflexlike responses to stimulation. In the lower animal forms, which have no brain centers, most actions are guided by the reflexes. Some animals have reflex reactions peculiar to their kind. If you grasp the tail of certain lizards, they respond by dropping it. A crab amputates an injured limb by an essentially reflex reaction. Reflexes lead an octopus to wrap its tentacles about its prey.

Reflexes are innate, or inherited. This does not mean that animals and men are capable of all reflex reactions from birth. A calf walks a few hours after being born, but a human baby waits until about a year or more after birth. Until this time, neither the baby's muscles nor his reflex mechanisms are mature enough to make walking possible.

Certain reflexes, however, are necessary for survival. These are present from the instant of birth. Touch a hungry infant on the cheek, and he turns in the direction of the stimulus. A touch on his lips produces the suckling reflexes. These involve the tongue, jaw, and palate. As soon as food enters his mouth, his saliva flows and a rhythmic swallowing begins. The stomach glands produce digestive fluids, and the stomach walls begin churning movements. This whole group of *nutritive* reflexes, plus the tendency to be restless when hungry, is sometimes called the "hunger instinct." Instincts then are interactions of unlearned combinations of reflexes.

Another set of reflexes present from birth are in the respiratory center, located in the lower portion of the brain, called the medulla oblongata. This center governs breathing. It may receive stimuli from various parts of the body. For example, a dash of cold water in your face may make you gasp. Sighing, sneezing, and coughing are all reflex interruptions of normal breathing.

The respiratory center is also influenced by certain chemical changes in the blood. When you exercise violently, the blood uses up oxygen more rapidly than normal. An excess of carbon dioxide accumulates in the blood and is carried to nerve centers. There it produces automatic discharges of impulses to the chest and diaphragm muscles. At once these muscles respond by pumping air into the lungs to provide the blood with the needed oxygen. This respiration reflex is so strong that it is impossible for a person to suffocate himself by merely holding his breath.

How Reflexes Are Changed

All reflexes are subject to change. In the human adult most reflex actions are modified, and comparatively few activities belong to the pure reflex type. Even such a simple reflex as winking may be reinforced or partly inhibited by voluntary central control. The motor paths which carry impulses for the winking reflex also conduct impulses for voluntary winking and closing of the eyelid. We may have an impulse to sneeze and at once inhibit this reflex. Again the reflex response itself may be altered (as when the knee jerk becomes weaker in illness). Or the response may remain the same but become associated with an entirely new starting point or stimulus. The process by which a new connection is established between a stimulus and a reflex is known as *conditioning*.

Famous studies of experimental conditioned reflexes were made by the Russian physiologist, Ivan Pavlov. Among other experiments, Pavlov rang a bell every time he fed meat to a certain dog. After a time the reflex which brought saliva to the dog's mouth at the taste of meat could be started by simply ringing the bell without giving the animal any meat. For the dog, the sound of the bell had become so closely associated with the sensation of tasting the meat that it was capable for a time of acting alone as a substitute for the normal stimulus of appetite.

Conditioned Reflexes Influence Habits

Some scientists regard conditioned reflexes as of fundamental importance in human development, especially in child training. They describe habits as consisting merely of patterns or systems of conditioned reflexes. The simple conditioned response, however, differs from an original response and from an established habit in being less regular and permanent.

The process of conditioning no doubt plays an important rôle in emotional life and in everyday likes and dislikes. A psychologist has reported the case of a girl who was intensely afraid of spiders. Even the most harmless little red mite would provoke a scream and symptoms of uncontrollable fear. It was found that when she was small she had been bitten by a large spider. The bite itself was not serious, and she might have taken it in a matter-of-fact way, except for her mother's excitement and distress. The girl's normal reflex from the pain of the bite became conditioned by her mother's excitement so that it resulted in extravagant terror at the mere sight of a spider.

Often we seek to justify a conditioned response and give it a rational basis, although its origin lies in some accidental association of events. A boy ate an apple and bit into a worm. Disgusted, he threw the apple away and for some time afterwards refused to eat apples in any form. He was "conditioned against apples." He tried to explain his dislike by saying that apples had a bad taste—but it was not really the taste of apples, but the association of worms that he objected to.

The Religious REVOLT *That* SPLIT CHRISTENDOM

Aging John Wycliffe, an English priest and teacher at Oxford, tells his Poor Priests to take the English translation of the Bible to the people. This distribution of the Bible stirred new thoughts about religion and helped lead to the Reformation.

REFORMATION. One of the greatest of all revolutions was the religious revolt in the 16th century, called the Reformation. This stormy, often brutal conflict separated the Christians of Western Europe into Protestants and Catholics. So far-reaching were the results of the separation that the Reformation has been called a turning point in history. It ushered in the Modern Age because, with their religious unity destroyed, people began to think in terms of their own regional interests. From the diversity of those interests arose new political, social, and economic problems and beliefs which form the roots of our modern nations.

Background of the Revolt

At the start of the 16th century Western Europe had only one religion, the Roman Catholic. The Catholic church was rich and powerful and had preserved Europe's classical culture (*see* Middle Ages). However, disputes and lax practices had grown up within the church, despite General Councils called to impose reforms (*see* Church, Christian).

These disturbing conditions led some churchmen to criticize the administration of the church and even to doubt some of its teachings, or *doctrines*. For example, the church insisted that it alone had the authority to interpret the meaning of the Bible for the people. As early as the 14th century, however, John Wycliffe, an English priest and teacher at Oxford University, declared that people had the right to read the Bible and interpret it for themselves.

MARTIN LUTHER

In his humble monk's garb, Luther nails his protest to the door of the church.

Despite protests by the church, followers of Wycliffe translated the Bible from Latin into English in 1382 and carried copies throughout the countryside (*see* Bible; Wycliffe).

Wycliffe's ideas spread into Bohemia, where John Huss, a Bohemian priest and educator, widely preached them in powerful sermons (*see* Huss). The work of Wycliffe and Huss greatly influenced a Saxon monk named Martin Luther.

Luther Sparks Revolt in Germany

Luther became the German leader of the Reformation. For some years he had protested that some of the clergy were selling *indulgences* (temporal pardon of sins) without making clear that people must also be sincerely repentant for their sins. He especially attacked the monk Johann Tetzel for deceiving the people. In 1517 the angry Luther wrote the Ninety-five Theses against indulgences and nailed them to the door of the church in Wittenberg. Luther developed new ideas opposed to the church.

CALVIN AND HIS COUNCIL

John Calvin, standing, leads the discussion of the Council of Geneva in 1549. His religious reforms imposed the strictest morality on the Swiss city. He also made it one of the most advanced cities of Europe. This scene is from P. A. Labouchere's painting.

He rejected the authority of the pope, and—like Wycliffe and Huss before him—set up the Bible as the sole source of Christian truth. He denied that priests had any power that laymen did not have. He declared that the vows taken by monks and nuns were not binding, and that monasteries should be abolished. He rejected the celibacy of the clergy. Of the seven sacraments he kept only two—baptism and the Lord's Supper (Eucharist)—and greatly modified the church's doctrine of the Eucharist.

The Reformation Spreads

When Pope Leo X condemned Luther's teachings in a *bull*, or papal decree, Luther burned the document and a copy of the church's canon law. Charles V, Holy Roman emperor, ordered him to recant in 1521. Luther declared he would not "until I'm convinced by the testimony of the Scriptures" (*see* Luther).

Other scholars helped to spread the Reformation. Philipp Melanchthon, Luther's colleague at the University of Wittenberg, became the chief theologian of the Reformation in Germany. Johann Reuchlin, of Heidelberg, enlarged the field of ideas by fostering the study of Hebrew and Greek. Knowledge of these ancient languages enabled people to read the Bible in its original forms and thus directly interpret the wording. From Johann Tauler, of Strasbourg, had come the mystic idea of "heart religion," which had led to Luther's doctrine of "justification by faith."

Reformation in Other Lands

Reformers in other lands were also zealous. Erasmus, the great Dutch forerunner of Luther, spurred the study of the early church through his printed editions of the Greek New Testament and writings of the church fathers. Lefèvre d' Étaples of France and Zwingli of Switzerland held views similar to Luther's (*see* Zwingli).

In England John Colet worked for reform within the church. John Calvin made Geneva the world center of the Presbyterian and Reformed churches (*see* Calvin)

Other Reasons for the Reformation

The Reformation was partly an outgrowth of the Renaissance, which had fostered religious skepticism (*see* Renaissance). The political situation in Europe also helped to extend the religious revolt, because many local rulers wanted their independence from the Holy Roman emperor, Charles V. Finally, many tradesmen and peasants were seeking more rights from rulers and landlords and resented the church because they believed that it favored their oppressors Throughout Western Europe there was unrest.

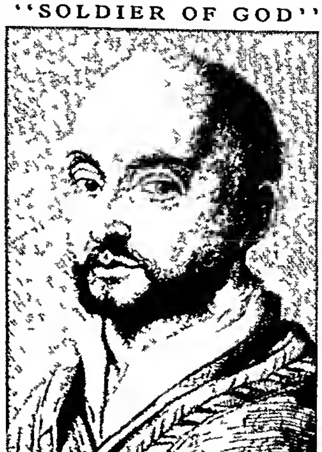
Luther's challenge of old religious doctrines and traditions became a rallying point for these forces of discontent and provided a motive for breaking established ties. Widely different groups, from princes to peasants, hailed him as their own special leader. Gradually, however, they all saw that he was not working for any special group, and so by 1530 many had drifted away from him in indifference or even in opposition By that time, however, the Reformation had spread beyond the control of even Luther.

Memorable Events in the Reformation

Although the Reformation swept through all Western Europe, the most dramatic events of this great religious revolt took place in Germany. It was in Wittenberg, Saxony, that Luther posted his Ninety-five Theses in 1517 and burned the pope's bull in 1520 A year later he was condemned by the Diet of Worms (*see* Luther). In 1525 German nobles, encouraged by Luther, put down the Peasants' Revolt.

Another great event in the Reformation occurred in 1529. That year the word *Protestant* was first used formally. In Germany the Diet of Spires decreed that changes of religion must stop and that the authority of the Catholic church be restored The Lutheran minority in the Diet, however, signed a protest against that decree. From this protest comes the modern term for the religious denominations of Protestants.

"SOLDIER OF GOD"



Ignatius de Loyola established the Jesuit order on military lines.

The fury and suffering of war added to the turmoil of the Reformation. Time and again Charles V fought to uphold the Holy Roman Empire against the claims of France and the German princes. He battled the Mohammedans who had advanced to the doors of Germany. Then he fought the Schmalkaldic War, 1546-47. Though he defeated the Protestants, he could

not turn back the movement of the Reformation (*see* Charles V, Holy Roman Emperor).

Peace treaties, however, followed the religious wars. The most important of these was the Peace of Augsburg in 1555. By that treaty Charles V was at last forced to grant to the ruler of each German state the right to choose Catholicism or Lutheranism. The choice was still imposed by the ruler as the state religion, but the treaty gave religious peace to Germany for over a half century (*see* Thirty Years' War).

The Lutheran faith spread chiefly in northern Germany and in Scandinavia. The Swiss, French, and Dutch faiths drew their Protestantism from a similar movement led by John Calvin a generation later. From this grew the zealous work of John Knox, who brought Presbyterianism to Scotland (*see* Knox). The English Reformation began when Henry VIII broke with the pope, who had refused to annul Henry's marriage to Catherine of Aragon (*see* Henry, Kings of England). The introduction of Protestant doctrine in the Church of England, however, did not take place until 1549, during the reign of Edward VI.

The Catholic Counter Reformation

At the beginning of the Reformation the Catholic church did not realize the extent of the movement. The authorities of the church considered it just another dissension or schism, like many earlier rifts. Soon, however, they saw the movement spreading from one country to another, with the people and rulers both joining the revolt.

The church took action. From 1545 to 1563 the Council of Trent issued decrees to correct abuses and to reaffirm ancient doctrines and traditions. The most vigorous program, however, was set up by the Society of Jesus, commonly called the Jesuits. This order was started in 1534 by Ignatius de Loyola, a Spanish nobleman and soldier who had become a monk (*see* Loyola). The Jesuit order was sanctioned by the pope in 1540. The highly trained, zealous members of the society greatly aided the revival of the church through their dynamic work as scholars, teachers, and missionaries.

Catholicism Rallies

A succession of able popes during the latter half of the 16th century followed the policy set in the Counter Reformation. Their conscientious administrations removed the incentive to revolt in lands still loyal.

By the close of the 16th century the Roman Catholic church had regained the faith of the people in half the lands it had lost to Protestantism. Europe was then divided between the two forms of Christianity by almost the same lines that exist today.

The IMPORTANCE *of* COLD *to* HEALTH *and* COMFORT

REFRIGERATION. An enclosed space is refrigerated when some means is used to make and keep it cooler than the surrounding air. The most familiar example of such a cooled space is the home refrigerator. Others are home freezers, cold storage warehouses, and refrigerated trucks and freight cars. Refrigeration also plays an important part in air conditioning and in various manufacturing processes.

Refrigeration is vital to health because it keeps foods fresh longer and retards decay. The cold stops or greatly slows down the bacterial action that causes decay. Meats, fruits, vegetables, and milk stay fresh because they are shipped in refrigerated cars and trucks to the markets. Perishable foods from overseas come in refrigerated ships. At their destination they may be held in cold storage warehouses until needed. Then store refrigerators, with temperatures ranging from below freezing to about 50° F., keep the foods fresh until they are sold; and home refrigerators and freezers preserve them until they are prepared for eating. (*See also* Air Conditioning; Cold Storage; Food Preservation.)

How Refrigeration Produces Cold

All substances, even very cold ones, have some heat in them. To cool them, some of this heat must be removed. Heat travels from a warm object to a cold one, so one way to cool an enclosed space might be to put a cold stone in it. The air would become cool, and the stone would become warm until the two temperatures became equal. A better way to cool a space is to put a cake of ice in it. The ice works better than the stone, because, pound for pound, it absorbs a much greater amount of heat. The heat from the air is "used up" in changing the *physical state* of the ice from a solid to a liquid.

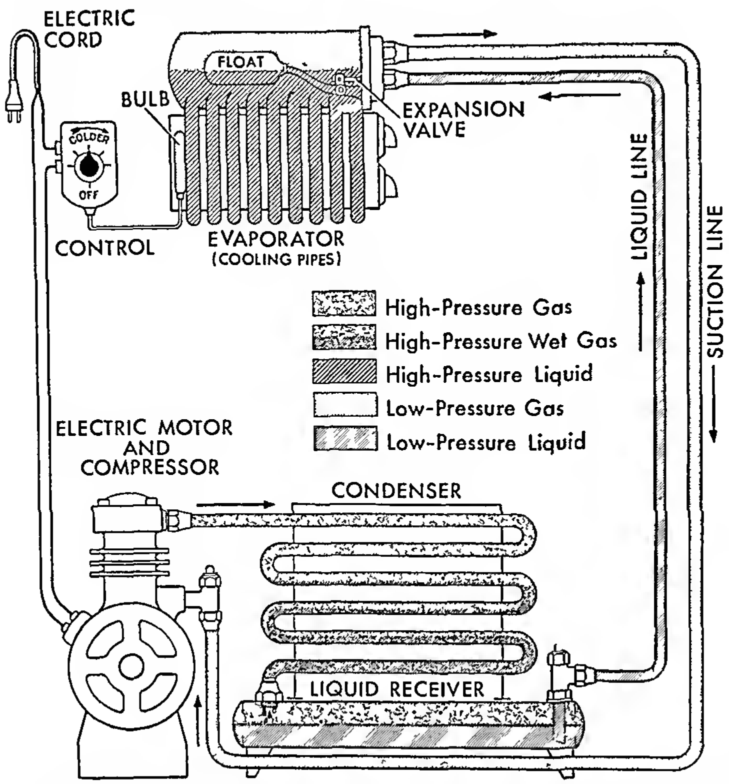
Another change of physical state in which heat is absorbed is evaporation—the change from liquid to vapor, or gas. When we sweat, body heat evaporates the perspiration. Air currents carry the warm vapor away, leaving the body cooler. The pleasant cooling effect of an alcohol rub or a witch hazel application comes from the rapid evaporation of these liquids.

In cooling by evaporation, the liquid vaporizes into gas and moves out into the atmosphere, carrying the heat with it. For continued cooling, more liquid must be supplied. However, if a gas can be condensed back into a liquid in a closed system, so that it is not lost into the air, the action can take place over and over again with no loss of fluid. Modern mechanical refrigerators use such a closed system. In them, the liquid evaporates to a gas and then condenses back to a liquid in a continuous cycle.

As a liquid boils, it gradually changes to gas. At sea level, where air pressure is 14.7 pounds per square inch, water boils into a gas (steam) at 212° F. Lower the pressure on any liquid and it boils at a lower temperature. Raise the pressure and higher temperatures are needed for boiling. These principles are called the *gas laws*, and they apply to any fluid—in either liquid or gaseous form. (*See also* Gas; Liquid Air.)

The fluids (called *refrigerants*) used in a closed refrigerating system boil and become gases at low temperatures and at sea level pressure. If more pres-

HOW THE ELECTRIC HOME REFRIGERATOR WORKS



This refrigeration cycle diagram shows how the refrigeration fluid does its work. It absorbs heat through the evaporator, inside the compartment, and releases heat through the condenser outside. As it does so, it changes from liquid to gas and back to liquid. Flow is regulated by the thermostat bulb.

sure is applied, the gases are compressed. Once compressed, they will change into liquid (condense) if their heat is removed.

The Electric Refrigerator

The modern electric home refrigerator produces cold by evaporating a liquid refrigerant. The evaporation takes place in the *evaporator*, or *freezer*, section of the closed pipe system. This section is located inside the cooled space. The liquid refrigerant, under heavy pressure and at a temperature of about 86° F., passes through an expansion valve into the evaporator, where the pressure is relatively low. The low pressure reduces the boiling point of the liquid, and some of it instantly vaporizes, or flash boils, into gas. The heat used in causing this flashing comes from the refrigerant liquid. The action reduces the temperature of both liquid and gas to about 5° F. As the rest of the liquid flows through the evaporator pipes, it slowly changes to gas, absorbing the heat needed for boiling from the refrigerated space.

From the evaporator the gas goes to a motor-driven *compressor*, which again puts the gas under high pressure. The energy used to compress the gas adds more heat. The hot, compressed gas then enters the *condenser* pipes, which are outside the refrigerated space. There the heat is carried off by the outside air around the pipes. The loss of heat changes the gas back to a liquid. It flows into a *receiver* tank, where it is ready to repeat the refrigerating cycle.

One method of temperature control uses a thermostat bulb inside the compartment. The bulb regulates the flow of the refrigerant. The evaporator becomes covered with ice from the moisture inside the box and must be defrosted. Older electric refrigerators are defrosted by shutting off the mechanism, opening the compartment, and allowing the ice to melt. Many modern refrigerators have automatic fast defrosting systems.

Refrigeration by Absorption

Because it uses a compressor, the electric refrigerator is a type of *compression* refrigeration. Another mechanical method of refrigeration is by *absorption*.

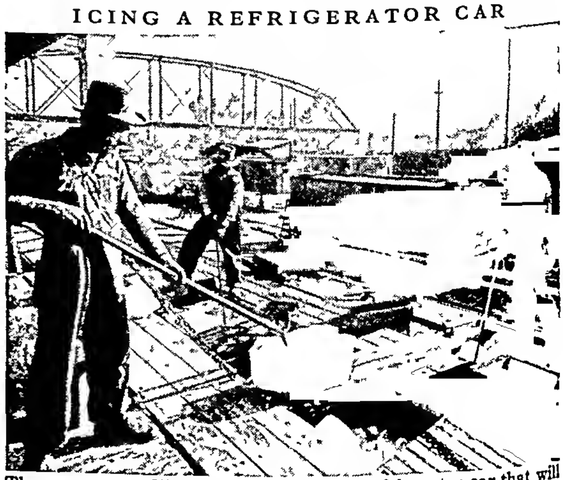
In the absorption system energy is furnished by heat. This system is used in some home refrigerators and commercial plants. Ammonia, dissolved in water, is the most frequently used refrigerant. Heat at the *generator* both increases pressure and drives the ammonia from the water as a gas. The gas is condensed and enters the evaporator, where in boiling again into gas it absorbs heat from the refrigerated space. The gas then flows to the *absorber*, where it is absorbed by the cooled water and flows on to the generator.

Secondary Refrigeration

Most refrigerators, cold storage warehouses, and artificial ice plants refrigerate with mechanical systems. Many of the cold storage warehouses and artificial ice plants use one (primary) refrigerant to cool another, or secondary, refrigerant, usually brine (salty water), which then is run in pipes through the spaces to be cooled.

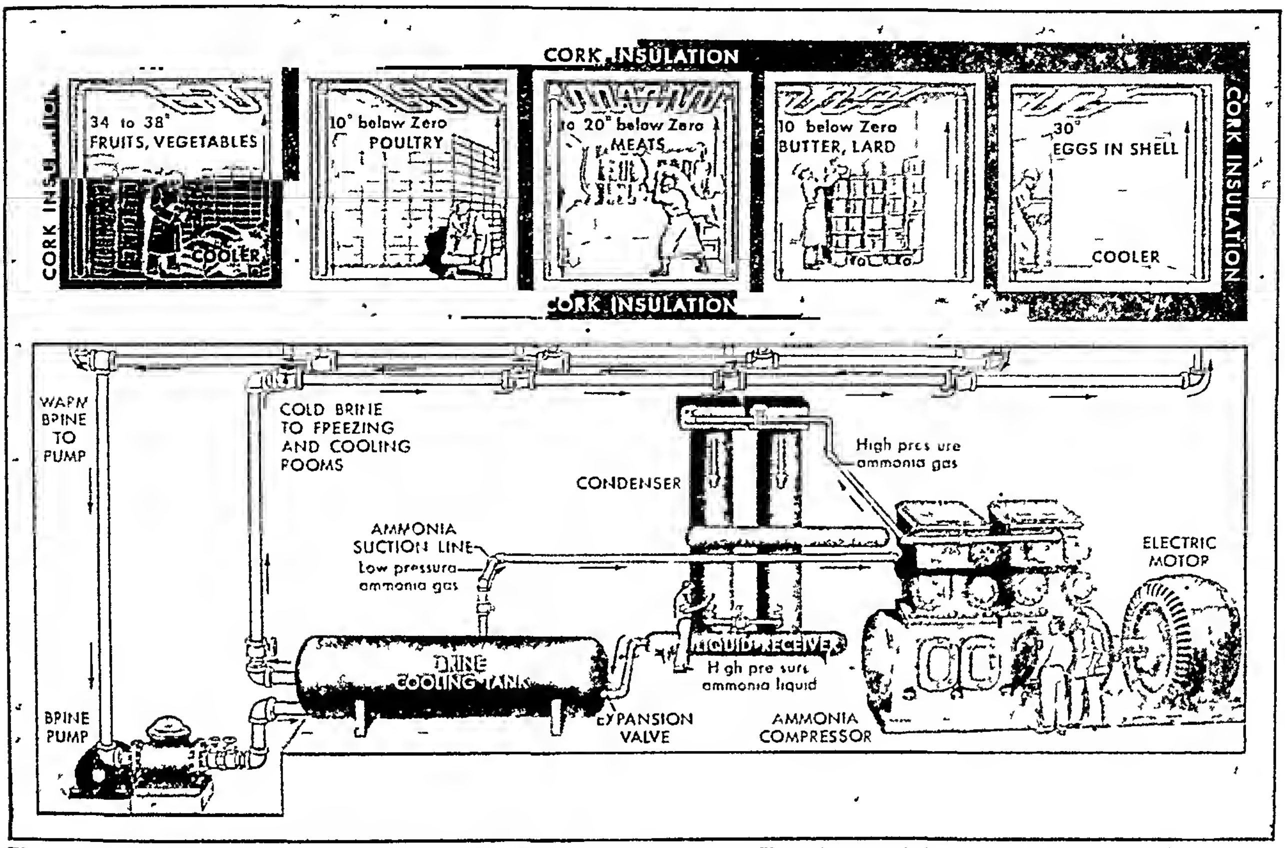
Brine is not particularly harmful to foods, while most primary refrigerants are poisonous or will spoil the flavor of foods should a leak occur. However, as refrigerating machines and materials are improved,

ICING A REFRIGERATOR CAR



These men are filling the ice bins of a refrigerator car that will carry California fruit and vegetables East. Some vegetables are also sprayed with chip ice to keep them crisply moist.

HOW COLD IS MADE AND CIRCULATED IN A WAREHOUSE



The circulation of ammonia and brine refrigerants are shown by the arrows. How these cool the storage rooms is told in the text. In this diagram the cold-making machinery is drawn larger than the cooling rooms in order to show clearly the circulation. To prevent undesired heat absorption, all pipes except those in the cooling rooms are covered with insulation.

more and more commercial installations are converting to the direct method of refrigerating.

Characteristics of Refrigerants

A desirable refrigerant would be nonpoisonous and nonflammable. None of the commonest fluids are both entirely nonpoisonous and nonflammable, but most are only slightly poisonous and none are highly explosive.

Freon (F-12), or dichlorodifluoromethane, is almost nonflammable and nonpoisonous. It is a common refrigerant for home refrigerators. Its companions, F-21 and F-114, have similar properties and also are widely used as refrigerants. Sulfur dioxide is another refrigerant often used in small refrigerators. Ammonia is used in both compression and absorption systems.

Nonmechanical Refrigeration

In the ice refrigerator melting ice first cools the air around it by absorbing heat from the air. The cooled air, because it is heavier, then drops into the refrigerated space and absorbs heat from it and its contents. The heated air rises to the ice chamber, transfers its heat to the ice, which causes the ice to melt further. The heat is carried out of the refrigerator in the drain water.

Another nonmechanical method is cooling with a mixture of ice and salt. The ice, in melting, dissolves the salt and combines with it to form brine. A mixture of 85 per cent ice and 15 per cent salt results in a brine that, so long as ice remains to which it can give up heat, maintains a temperature of 11° F. This mixture is sometimes used to freeze ice cream, which freezes at about 26° F., or well below the 32° F. melting point of ice alone (*see* Freezing).

Solid carbon dioxide ("dry ice"), which has a temperature of 110° F. below zero, is often used to keep ice cream and foods frozen while being shipped. The advantage in using it lies in the fact that dry ice evaporates, or *sublimes*, directly into a gas that passes off in the air and so does not leave a wet residue behind. (For an explanation of how dry ice is made, *see* Carbon Dioxide.)

How Refrigeration Developed

For centuries cool caves, wells, running streams, and holes in the earth were the only places to refrigerate food. Then someone discovered, perhaps accidentally, that liquid in a porous container left in a dry wind became cool. The seepage through the porous walls evaporated and the wind absorbed the warm vapor. Snow was used also, but in hot weather the nearest snow lay far away on the mountaintops. Some rich Romans kept slaves running from the mountains to their villas with snow to cool their wines.

By 1775 men were storing ice cut from lakes, ponds, and rivers in caves, cellars, and buildings for use in summer. They found that if they packed sawdust, wood shavings, or cork around the ice or in the building walls it slowed down the passage of warm air that would melt the ice (*see* Cork; Glass). In the early 1800's Frederic Tudor, an enterprising Massa-

chusetts man, shipped ice to the West Indies and New Orleans. By 1821 ice cream frozen with Massachusetts ice was being made and sold in New Orleans.

In 1823 Michael Faraday discovered that certain gases under constant pressure would condense as they cooled (*see* Faraday). The first compression ice-making machine using this principle was developed in 1834 by Jacob Perkins, of Massachusetts. His refrigerant was ether. In 1851 John Gorrie, a Florida physician, patented a cold-air machine for cooling sickrooms. Ammonia was first successfully used in a compression machine in Germany in 1873; David Boyle, an American, used it in a machine two years later.

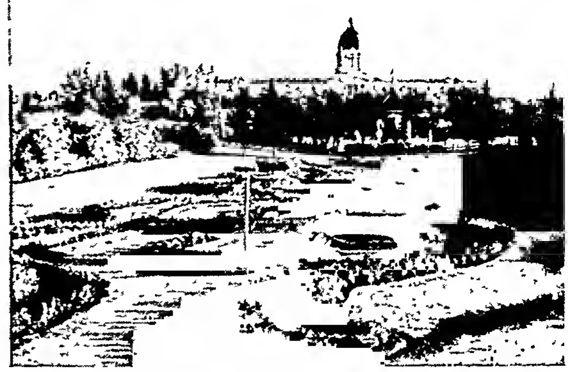
In the meantime more and more natural ice was called for. In 1857 an ordinary boxcar, fitted with ice bins, was used to haul a load of refrigerated beef from Chicago to the East. A similarly equipped car hauled southern Illinois fruit to Chicago in 1866. The first patent for a refrigerated freight car was granted in 1867. In 1952 a fleet of cars that could be mechanically cooled or warmed was put in service.

The successful shipping of meats, fruits, milk, and vegetables under refrigeration made more foods available to everyone. No longer was it necessary for every community to operate a slaughterhouse. Under refrigeration perishable goods could be carried across a continent and sold fresh upon arrival. In the 1880's marine refrigeration had so far developed that a shipload of fresh New Zealand mutton was received in the British Isles, half a world away. (*See also* Fruit and Fruit Growing; Meat Packing.)

It took the extremely mild winter of 1889–90 and the consequent shortage of ice to bring mechanical refrigeration into wide use. The demand for ice led to the building and operation of many artificial ice-making plants. The first practical automatic home refrigerator was placed on sale in America in 1918. American homes today have refrigerators that will freeze ice cubes and that will keep perishables both below and above freezing temperatures. Foods can be kept in them for a week or more. Freezing cabinets can keep many foods indefinitely. Most communities have refrigerated warehouses that rent lockers. There families can keep large supplies of food at freezing temperatures. Families can buy and freeze foods "in season," when they are plentiful and cheap, and eat them anytime throughout the year. Many foods are packaged and frozen immediately after harvest. These are sold throughout the year from the freezing cabinets of stores. Very little food value is lost in quick freezing (*see* Vitamins).

REGINA (*rē-gī'nȧ*), SASKATCHEWAN. A glance at a map of Saskatchewan shows a spider web of railways radiating from Regina. This makes clear why this city is the commercial as well as the political capital of the province. Every year millions of dollars' worth of hardware, groceries, clothing, agricultural implements, and many other products go out from Regina to supply the surrounding farming communities. Grain elevators, flour mills, woodworking establishments, automobile assembly plants, paint, varnish, and glass works, foundries, machine shops, and oil refineries are among the many industrial plants.

BEAUTY ON THE PRAIRIE



Saskatchewan's capitol dome looms above a beautiful park in Regina. In the 1880's the site was a treeless plain. All trees, shrubs, and flowers have been planted since.

Like many other cities of the Canadian Northwest, Regina has adopted municipal ownership. It owns the street railway, light and power plant, waterworks, and stockyards. The buildings of the provincial parliament stand in a beautiful park. There are four colleges—Regina, St. Chad's, Luther, and Campion.

The townsite of Regina was laid out in 1883 to serve as the seat of government of the Northwest Territories and as headquarters for the Royal Northwest (now Royal Canadian) Mounted Police. In 1905 Regina was made capital of the new province of Saskatchewan. Population (1951 census), 71,319.

REIMS (English *rēmz*, French *rǎṅs*), FRANCE. During the first World War, Reims was blasted into ruins. Only about a hundred houses were left fit to live in. For more than two years several thousands of its residents huddled underground in the vast wine cellars tunneled in the chalk beneath the city. In 1917 complete evacuation was ordered.

After the war Reims was rebuilt as a model city, with a garden suburb for industrial workers. The war-damaged cathedral was restored by 1937 through the generosity of John D. Rockefeller, Jr.

In the second World War, Reims escaped damage. It was here that Germany signed the treaty of surrender to the Allies on May 7, 1945 (*see* World War, Second).

Reims (also spelled Rheims) is situated on the Vesle River in northeastern France, about a hundred miles from Paris. It began as the chief settlement of a Gallic people known as the Remi. In 57 B.C., it allied itself with Julius Caesar in the Gallic Wars. In medieval times it became a center of Christianity, and Clovis and other Frankish kings were anointed there (*see* Clovis).

Little of the old city has remained—only the ancient Mars Gate and the glorious medieval cathedral. The gate, a triumphal archway of Roman days, was erected in the 3d or 4th century. The famous cathedral (Notre Dame of Reims) was built in the 13th

century From that time on, almost every king of France was crowned and consecrated there, for the city had become the residence of the chief archbishop of the realm. It was there that Joan of Arc brought Charles VII for his coronation (*see* Joan of Arc).

Today, Reims has important industries, producing champagne, woolen fabrics, soap, paper, glass bottles, and wooden wine casks. Population (1946 census), 106,081.

A REINDEER WITH ANTLERS "IN THE VELVET"

This Lapp herder has caught a doe for milking. His lasso and moccasins are made from reindeer skin. The moccasin toes are turned up to help hold skis. The doe's new antlers are covered with a soft fuzzy skin called "velvet."

REINDEER. Most American children hear stories about Santa Claus and his swift reindeer. In one of these the reindeer fly through the air from the North Pole on Christmas Eve with a sled full of presents for children. This story reflects several truths about reindeer. Reindeer live in the frozen Arctic North. They can pull sleds. And in the northernmost parts of Europe and Asia, they are man's most useful animal.

Reindeer furnish milk, cheese, and meat for food. They can haul loads of 300 pounds and more over frozen ground at nine or ten miles an hour for several hours. People make clothing, moccasins, leggings, blankets, harness, and other equipment from their hides. They use the tough sinews for thread.

Most of the reindeer of Europe and Asia are domesticated. Almost exactly the same kind of animal is found wild in the Arctic regions of North America. These animals are called *caribou.*

How Reindeer Live

Reindeer belong to the deer family. But they have heavier bodies than most deer. The legs are shorter and thicker, and they have broad hoofs which support them on snow.

In winter reindeer eat a kind of lichen, called reindeer moss. They scent the growth buried under the snow and dig down to it with their broad, sharp hoofs. One deer may eat 27 pounds in a day. The lichens grow slowly and require years to replace themselves, so that reindeer must move constantly to find fresh pasture. Usually in summer they migrate from their winter feeding grounds on higher land to the coastal tundra. There they fatten at an astonishing rate on grass and other vegetation that grows in the short, bright Arctic summer.

Unlike most deer, both male and female reindeer have antlers. A stag grows to full size in four or five years. He may weigh about 300 pounds and be from four to five feet high at the shoulders. The hair is dense and springy. It is grayish brown, with white on the under parts.

A BUCK WITH FULL-GROWN ANTLERS

The reindeer's sturdy legs and broad hoofs make him a stout draft animal. The clipped ear is an owner's brand.

Imported Herds for Alaskan Eskimos

The American caribou has never been domesticated. But reindeer have been imported from Siberia to provide herds for Eskimos in Alaska and parts of Arctic Canada. The United States Office of Education brought 1,280 animals to Alaska between 1892 and 1902. The present herds of several hundred thousands in Alaska and Canada are descended from these animals.

Herders from Lapland were hired to teach the Alaskan natives to care for the herds. Each native is trained for four years, before he receives animals of his own. Eskimo tribes move with the herds, guarding them from wolves and thieves. Dogs are trained to help. Plans for marketing the meat in the United States failed.

Scientific name of reindeer, *Rangifer tarandus.* (For illustration in color, *see* Arctic Regions.)

SCIENCE'S *Revolutionary* THEORY *of* RELATIVITY

RELATIVITY. Among the outstanding advances in science will always stand Albert Einstein's theories of relativity. They forced revision of all fundamental thinking about time and space. They brought changes in many statements of natural law, including Newton's law of gravitation. And the theories gave scientists the mathematical framework they needed for atomic research and for releasing atomic energy.

At first, it was said that only a dozen men in the world could understand these revolutionary theories. This was only partly correct. It is true that the relativity theory employs the highest branches of mathematics. But today thousands of scientists understand the theories; and anyone can get a good idea of relativity by simply thinking the matter through.

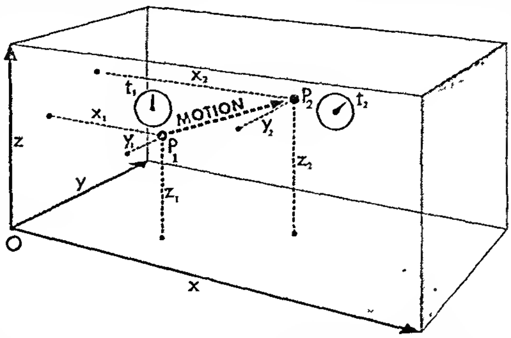


Fig. 1.—To describe a motion as everyone did in the days before Einstein, an observer first selects a starting point, called the origin (O), for measurements. Then he sets up three measuring lines (*x, y, and z*) at right angles to each other, corresponding to the three dimensions of space (length, breadth, and height). These lines define three faces of a solid, which is big enough to contain the motion; and any position in space, such as P_1, can be stated by measuring how far it is from three faces of the solid adjoining the origin. Thus the lines representing the three dimensions of space provide a *frame of reference.*

Now suppose that at time t_1, an object is at position P_1. At time t_2 it has moved to position P_2. This motion can be described in terms of the two sets of measurements—$x_1\ y_1\ z_1\ (t_1)$ and $x_2\ y_2\ z_2\ (t_2)$—for the respective positions in space at the two instants in time.

The Michelson-Morley Test

Einstein's thinking grew out of a number of scientific puzzles, especially about light. For many years scientists had believed that light traveled across space as waves in an elastic, weightless, and invisible medium called the *luminiferous ether.* They thought the earth moved ("drifted") through the ether; and in 1887 A. A. Michelson and E. W. Morley tried to measure this drift (*see* Michelson). But no sign of motion appeared. If light was carried by an ether, the earth seemed to be standing still in it.

Of all the attempts made to explain this result, the most promising was offered by the Dutch physicist, H. A. Lorentz. He suggested that matter which moved through the ether might become slightly shortened in the direction of motion. If this affected Michelson's instrument by just the right amount, it would nullify the experiment.

The very suggestion raised doubt about the certainty of any scientific measurement, and many efforts were made to detect such a contraction. But none succeeded; and scientists were left with this haunting doubt about the accuracy of all measurement until Einstein offered his relativity theory as an answer in 1905.

Einstein's Approach to the Problem

Einstein started by questioning the current method for measuring motion. This method is shown in Fig. 1, and it could be used in either of two ways. A stationary observer could check a motion directly against his frame of reference. A moving observer would have to measure an observed motion against a frame he carried with him, then allow for his motion against some *stationary* frame. This would give a true record of the observed motion, provided the stationary frame remained fixed and invariable in space and time.

At the time, all scientists assumed that the frame provided by empty space did remain fixed and invariable (except for Lorentz's disturbing suggestion). But now Einstein asked, can we be so sure of this? We face a puzzle, and in spite of our best efforts, we cannot work it out within such a frame. Therefore might it not be wise to examine the frame itself, to see if it is as sound as we think it is?

Since human beings have accepted three-dimensional space and the march of time without question through all the ages, Einstein's proposal seems unthinkable at first glance. But a simple example will show why and how the supposed invariability of space and time can be brought into question.

Suppose that somewhere in actual three-dimensional space there is a vast plane inhabited by dotlike creatures who can understand nothing but the *two* dimensions *x* and *y* of their plane. Let us call these creatures dwellers in Flatland, after the title of a noted book once written about them; and let us follow one such creature as he does some experimenting in his flat world.

Experimenting in Flatland and Curvedland

Suppose he travels along the straight line between two Flatland cities, A and B. He goes at a steady pace and uses a yardstick to measure the distance. He takes 100 days for the journey; and his yardstick measuring gives the distance as 1,000 miles.

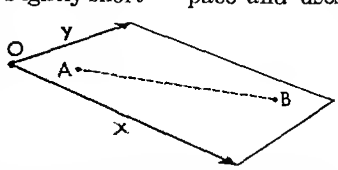


Fig. 2.—A dotlike creature living in a plane (Flatland) wants to measure the distance between A and B. He can do so readily, as explained in the article.

Now he tries another test. He uses a radar outfit to get a reflected signal from A, and finds that the signal passes each way through the intervening space in 1/186th of a second. Since radar signals travel at the speed of light (186,000 miles a second), this means a distance of 1,000 miles. The radar test has confirmed the measure made with the yardstick.

Now imagine this creature transferred to the surface of a huge hollow sphere, comparable in size to the earth. The sphere is in three-dimensional space, and radio signals traverse this space. The transferred Flatlander cannot realize this or other aspects of his actual situation; but he will feel at home because the sphere is huge, and its curved surface

seems flat. Suppose we call his new surroundings Curvedland, and see what will happen if he repeats his distance tests between Curvedland cities C and D.

Now he cannot move along the actual shortest distance between C and D. It lies inside the curved surface, in the third dimension of space, as shown in Fig. 3. The shortest distance he can find will be the *great circle* between C and D on the surface of the sphere (*see* Navigation).

Suppose his travel time is 120 days, and the distance measures 1,200 miles. Now he makes a radar test; and the result surprises him. As shown in Fig. 4, the signal will follow the actual shortest distance and give a measure (let us say) of only 1,000 miles.

This is a puzzling outcome—and how can he explain it? First, he might assume that his yardstick and clock measurements are correct and try to explain what happened to the radar signal. But he would certainly fail, because he can never imagine what really did happen—that is, the signal left his two-dimensional world and traveled through the third dimension (unknowable to him) of space inside the surface of the sphere.

Secondly, after his first explanation fails, he can accept the result of the radar test as correct and change his other measurements to be consistent. This he can do by assuming that when he moved from Flatland to Curvedland, his yardstick shrank just enough to measure 1,000 miles as 1,200. (This corresponds to the Lorentz contraction.) He would also have to assume that the days he used as his measure of travel time had shortened somehow, and had given him a count of 120 instead of 100. Then all his experimental results would be consistent.

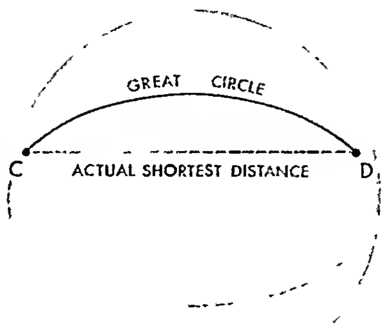
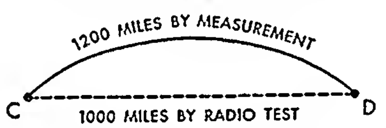


Fig. 3.—For a Curvedlander living on the surface of a hollow sphere, the shortest distance between C and D is part of a great circle. The actual shortest distance passes through the space inside the sphere.

Fig. 4.—A radar signal between C and D would traverse the shortest distance inside the sphere. The Curvedlander could not understand this because he knows nothing of the third dimension which the signal traverses.



This puzzle is only one of many that would arise if the Flatlander continues traveling in Curvedland and making tests. Perhaps strangest of all, if he keeps going long enough, he would be coming to his own back door. This would happen because his supposedly flat space actually is *closed* and *limited*. The great circles which he mistakes for straight lines close on themselves and are limited in length.

Now suppose some "Flatland Einstein," a mathematical genius, studies these matters. He can use as many space dimensions as he likes in working problems even though he can only *visualize* two. So he devises an explanation, using the shortened yardstick and shortened days. This not only explains the radar signal: it explains the far greater puzzles which would have arisen on a longer journey. His explanation actually amounts to treating all the events as happening in three-dimensional space. But he must state it in mathematical terms, because neither he nor any other Flatlander can think in terms of an actual third dimension, one which they can "see" as existing.

Einstein's Fundamental Proposal

Einstein proposed much this same course in dealing with the Michelson-Morley experiment. Indeed, he showed that scientists had no other choice. In the ether-drift experiment, they had expected light to *appear* speeded up whenever it moved inside the apparatus *against* the earth's motion. The apparent new speed would be the sum of light's actual speed through empty space, plus the speed of the earth advancing to meet it.

They had failed to detect such an effect. Light seemed to have the same speed, regardless of the direction in which it moved relative to the earth's motion. And the one chance to explain this and still retain the ether theory had failed, since no evidence of the Lorentz contraction could be found. Therefore, scientists had to accept the other explanation. Since the speed of light remains constant, regardless of the earth's motion or any other, measurements of motion must be made changeable so that problems would still "figure out" in agreement with observed facts.

Variable Space and Time

This meant accepting the Lorentz contraction (corresponding to the Curvedlander's contracted yardstick) except that Einstein removed the unprovable feature. Lorentz had suggested a contraction *of matter*, and this had not been found. Einstein proposed that the dimensions of *space itself* change with an observer's speed.

Next, he proved that the rest of the Curvedlander's second explanation would have to be accepted too. He showed by an acute mathematical argument that if the speed of light is invariable, and space itself changes with speed of motion, then man's measure of time must change too.

This might seem at first to destroy all certainty in science. How could any speed of motion be measured with certainty, when the very units used to measure it were changeable? Very easily, Einstein said. One invariable fact of Nature remained—the constant speed of light. All other speeds could be stated as fractions of it. Then this fraction could be used as a "correction factor" in every measure of space or time which might occur in a motion problem.

One great task remained for Einstein. It would be necessary to find what mathematical forms the "correction factors" should take, so that calculated motions would agree with observed facts. For his attack upon this problem, Einstein decided that since both space and time were to be considered as variable, he would treat them together as aspects of a four-dimensional, space-time *continuum*.

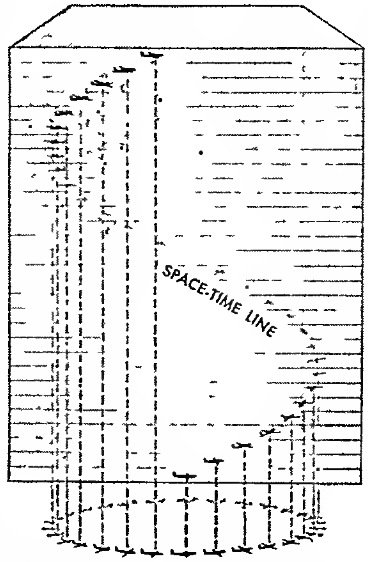
His treatment cannot be explained fully without use of advanced mathematics. Neither can helpful pictorial examples of the full meaning be given. They would have to be drawn in four dimensions, and this is impossible. But a reasonably good idea of the continuum may be given with an example limited to three dimensions.

Consider first an airplane circling in level flight. Notice that only two space dimensions, x and y, need be used to record the airplane's successive positions in space. The third dimension (z) may be used for time. Now a three-dimensional continuum can be constructed as follows:

Expose one photographic plate every minute to take a picture of the airplane from below. Develop the plates and stack them in order. Then connect the successive positions of the airplane with a continuous line.

The stacks of plates may be called a *three-dimensional continuum*. The line joining the airplane positions rises in corkscrew fashion through it, showing the plane's motion in two dimensions of space and in the "dimension" time.

MAKING A WORLD LINE



Here the circling flight of an airplane (at the bottom) is recorded as a corkscrew space-time line. The article tells how such a line can be made and used for relativity calculations.

This sort of line formed the heart of Einstein's treatment (except that his lines were developed in a four-dimensional continuum and have meaning only in mathematical terms). A good term for them is *world lines*. In a four-dimensional continuum the track of a moving object like an airplane, or the orbit of a planet, or the path of a light ray is a world line.

The rest of his task consisted of restating previously accepted laws of nature as world lines and seeing whether the new statements agreed with all observed facts. In this he succeeded brilliantly.

His equations and formulas worked perfectly. And where they predicted a result at variance with older theory, tests proved Einstein's formulas to be correct.

Einstein's work on motion in the four-dimensional continuum is known as his *special theory* of relativity. He extended this work to cover other phenomena in what is called his *general theory* of relativity.

Einstein's Theory of Gravitation

An outstanding triumph of the general theory was a new explanation of gravitation. Ever since Newton's day, the "force of gravity" had stood apart from all other natural forces in that it acted alike on all kinds of matter, whereas the action of all other forces varied according to the kind of matter. Countless unsuccessful efforts had been made to explain this difference.

Einstein tried a radically different approach. Again his method was mathematical and can be explained completely only in such terms. But it amounted roughly to assuming that matter *warps the continuum* according to the amount (mass) which exists in any locality. Then all motion along world lines in the vicinity must follow the warp. A limited version of the idea can be given by using a sheet of stretched rubber to represent the continuum, as shown in the picture at the bottom of this page.

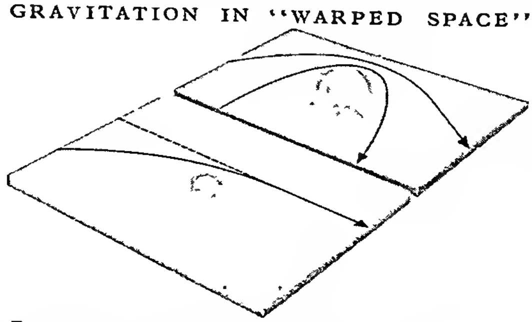
The response to warping usually gave the same results in computing problems as response to Newton's "force of gravity." But some differences came to light and in every case Einstein's theory worked better. For one thing, it cleared up a puzzling aspect of the planet Mercury's motions in space. This planet follows an elliptical orbit around the sun; and the ellipse itself rotates 547 seconds of arc (about 1/6th of a degree) a century. Calculations based on Newton's theory failed to account for 43 seconds of this motion. Einstein's theory accounted for all of it.

Mass and Energy, Light, and "Curved Space"

In converting older laws of nature to relativistic terms, Einstein found it necessary to treat mass (matter) and energy as potentially interchangeable, according to the law $E=mc^2$. This formula proved immensely helpful in atomic energy research, leading to the invention of the atomic bomb (*see* Atoms).

Another triumph came in connection with light. If world lines must follow warps in space, beams of light passing near the sun should be deflected slightly. This prediction of a stellar shift was verified by observations of solar eclipses in 1919 and 1922.

GRAVITATION IN "WARPED SPACE"



For a partial illustration of Einstein's explanation of gravitation, imagine two pieces of rubber stretched tightly on frames. On one (left) a small ball (small mass) warps the rubber slightly. On the other (right) a large ball (large mass) produces greater warp. Now, if marbles are rolled across the warped portions, they will alter their motion as shown. If the marble in the left-hand picture represented light from a star passing the sun, the star would appear in the position marked by the broken line; that is, there will appear to be a *stellar shift*. Einstein's explanation assumes a similar working of the continuum.

Another consequence of the theory is a shift of spectral lines toward the red, caused by the huge masses in stars "dragging back" upon their light. This effect is hard to distinguish from a "red shift" which suggests that the universe may be expanding (*see* Astronomy). But the prediction has been substantially verified.

Finally, if matter is distributed in a certain way throughout the universe, it will warp all world lines which are long enough, into

closed curves. Then space will be closed and curved, as Curvedland space was for the Flatlander. Thus, if light can keep traveling for many billions of years, it will finally return to its starting point.

About 1929, Einstein began to develop his *unified field theory.* In this work he sought to link the phenomena of light, motion, gravity, and electromagnetism in a single theory. In 1949 he developed equations that accomplished this task. He called his work "a generalized theory of gravitation." He was not then able to suggest experimental checks for the theory. This would have to be done and, to complete his work, it remained for him to incorporate the quantum theory of atomic physics in the unified field theory.

Religions of the World. Of the world's great religions Christianity has by far the greatest number of believers. Nearly one-third of the world's population—about 700 million people—profess some form of this faith. In 2,000 years of missionary work, migration, and conquest, its adherents have carried its teachings to every continent. Today Europe, America, and Australia are overwhelmingly Christian, while the number in Asia and Africa is steadily increasing.

The number of Mohammedans is also increasing. Military conquest and missionary work carried this faith from its birthplace in Arabia across northern Africa into Spain, through Asia Minor into European Turkey and the Balkans, and east across Asia to the East Indies. Now more than 300 million Moslems answer the daily call to prayer.

Numerically greater than the Mohammedans, but less aggressive, are the 350 million Confucianists and Taoists of China. They are the followers of two Chinese teachers, Confucius and Lao-Tse. Both sought to establish a workable system of practical morality. Confucius stressed social service, and Lao-Tse passive individualism, as the means of attaining the most good (*see* Confucius), but the original teachings of Lao-Tse have been buried under a mass of superstition and magical practises.

Hinduism is the chief religion of India, with about 250 million adherents (*see* Hinduism). Buddhism also arose in India and spread over central and eastern Asia. Now it has some 150 million adherents (*see* Buddha). In China it merged with Confucianism and Taoism. In Japan it blended with the pagan worship called Shinto (*see* Japan). In 1867 the Japanese government made Shinto the state religion; but in 1945 General MacArthur withdrew government support and forbade teaching religion in the schools. On Jan. 1, 1946, Emperor Hirohito admitted that Shinto teaching of his divinity was "a false conception."

Judaism, the first of the great monotheistic religions, was carried westward by the Jewish migrations from Palestine. About half of the 11 million Jews in the world live in the United States.

The Christian church has three main divisions, the Roman Catholic, Eastern Orthodox, and Protestant churches (*see* Church). No authoritative statistics have ever been assembled. Latest unofficial estimates put the numbers of adherents at about 300 million, 144 million, and 200 million respectively.

The Roman Catholic church thus claims nearly half the total number of Christians. The population of Europe, Latin America, and Oceania is predominantly Catholic, with the Eastern Orthodox church leading in the Balkan peninsula, Asia Minor, Syria, and Russia. The Roman Catholic church includes Greek, Hellenic, Russian, Serbian, Bulgarian, Syrian, Rumanian, and other churches. Various other churches, including the Armenian, Nestorian, Coptic, and Abyssinian, which do not belong to the Eastern Orthodox communion, are generally grouped with this division.

The largest of the Protestant denominations resulting from the Reformation begun in 1517 is the Lutheran church. It claims over 80 million adherents. About two-thirds of them live in Germany and Scandinavia. Methodists, Presbyterians, Anglicans (including Protestant Episcopalians in the United States), and Baptists follow. Other numerically important denominations are the Disciples of Christ (Campbellites), Congregationalists, Mennonites, Friends (Quakers), Unitarians, and the Latter-Day Saints (Mormons).

Apart from the Lutherans, the greatest membership of these Protestant denominations is found in English-speaking countries. In Great Britain and North America the Protestants make up nearly two-thirds of the total population. One remarkable recent religious movement is the growth of the Christian Science Church, founded by Mrs. Mary Baker Eddy.

A MIRROR PORTRAIT

Rembrandt painted this portrait of himself. He made more than 50 such studies, in constant efforts to improve his art.

Rembrandt (*rĕm'bränt*) (1606-1669). Ten years before Shakespeare died, a boy who was to become one of the greatest painters of all time was born in Leyden, Holland. His full name was Rembrandt Harmenszoon van Rijn (pronounced *vän rīn*).

Rembrandt's father was a miller. He wanted the boy to follow a learned profession, but let him take up painting when he showed no interest in schooling. Rembrandt studied with artists in both Leyden and Amsterdam. His early work was devoted to showing the

This portrait displays Rembrandt's technical skill and his distinguished style as a portrait painter. The artist painted it about 1632–33, at the height of his popularity. The original, done in oil on wood, hangs in the Academy of Fine Arts in Vienna.

lines, light and shade, and color of the people he saw about him. He made studies of every sort of person to be seen in the crowded streets. Jewish beggars and venerable rabbis, prosperous merchants, soldiers, cripples were his subjects. When he had no one else, he used himself as a model. It is estimated that he painted between 50 and 60 portraits of himself, not through any sort of vanity, but because he could use his own face as a mirror of all feelings.

In 1631 Rembrandt's work had become so well known that he moved to Amsterdam. Numerous orders for portraits were given to him as the foremost portrait painter of the day. The beautiful fair-haired Saskia Van Uylenborch, whom he married in 1634, was the model for many of his more fanciful pictures. In addition to portraits and set pieces, Rembrandt attained fame for his landscapes, while as an etcher he ranks among the foremost of all times.

It is impossible to describe the 700 pictures that Rembrandt produced, of which about 500 remain. There is one, however, which shows his powers so well that an appreciation of its excellence opens the eyes to an appreciation of all his work. That one is called 'The Night Watch' and is in the Royal Museum of Amsterdam. It is a life-sized picture of a group of 29 city guardsmen issuing for a sortie. Each man is painted with the loving care that Rembrandt gave to single portraits, and yet the composition is so wonderful that the separate figures are made second in interest to the effect of the whole. The canvas is brilliant with color, movement, and light. In the foreground are two men, one in bright yellow and the other in black. Rembrandt knew how to let the shadow of the one tone down the high light of the other. In the center of the painting is a little girl dressed in yellow. Many people wonder what she is doing all alone in that crowd of men. Joseph Israels, the great Dutch artist, says: "If Rembrandt could have heard them he would have answered with a laugh, 'Don't you see that I only wanted this child as a focus for the light and a contrast with all the downward lines and dark colors?' "

During the later years of his life Rembrandt lost some of his popularity. This was due to many reasons. The Thirty Years' War had impoverished all northern Europe, and pictures and portraits more than ever were luxuries. Many people objected to his free, independent method of work, and to his subjects. They thought that he should follow after the painters of Italy, that he should paint subjects from the history and mythology of Greece and Rome instead of from Dutch themes. Then, too, Rembrandt displeased many staid burghers by his extravagance in buying pictures of other artists. His vast collection of paintings was sold at auction before his death and he died poor and obscure. But for us he remains, as Israels says, "the true type of artist, free, untrammeled by traditions." His fame increases from year to year and his paintings are becoming almost priceless.

Besides 'The Night Watch' (which actually represents a daytime sortie by Capt. Banning Cocq's shooting company), some of Rembrandt's chief works are: 'The Wedding of Samson' (Dresden); 'St. Paul in Prison' (Stuttgart); 'Anatomy Lesson' (The Hague); 'Syndics of the Cloth Hall' (Amsterdam), and 'Christ at Emmaus' (Paris). Famous Rembrandts in the United States include, in addition to many fine portraits, 'Pilate Washing His Hands' (Metropolitan Museum of Art, New York City); 'Young Girl at an Open Half-Door' (Art Institute, Chicago); 'Lucretia' (Institute of Arts, Minneapolis); 'The Visitation' (Institute of Arts, Detroit), and 'The Mill' (Widener Collection, Philadelphia).

The DAWNING *of Our* MODERN AGE *in* EUROPE

How the Middle Ages Ended with the Recovery of Ancient Civilization and How Europeans Began Their Expansion Over the World

RENAISSANCE (*rĕn-ā-säns'*). In a narrow sense, the term Renaissance (meaning "rebirth") refers to the revival, in the 14th and 15th centuries, of Greek and Roman culture. Historians formerly drew a sharp contrast between the so-called "darkness" of the Middle Ages and the brilliance of the Renaissance, when Europe was supposed to have become quickly enlightened by the recovery of classical civilization (*see* Feudalism; Middle Ages). It is now known that the change from the Middle Ages to the Renaissance was gradual and less important than historians formerly believed. It is also recognized that there were in operation many important forces besides the revival of classical culture. Nevertheless, the fuller appreciation of the writings, the arts, and the attitudes of mind of the Greeks and the Romans is still viewed as perhaps the most distinctive feature of the period. And so the first concern of this article must be with the revival of ancient culture.

Dante (1265–1321), who wrote his soul-stirring 'Divine Comedy' in Italian instead of Latin, was "the glimmer of the dawn" of the Renaissance.

Francesco Petrarch (1304–1374) was its real initiator in the field of literature and learning. He not only wrote many exquisite sonnets in Italian, but he "aroused classical antiquity from its long winter sleep," and gave direction to the talents of a hundred others. Like Dante he was a citizen of Florence, that wonderful city on the river Arno, the Athens of Italy; but both spent most of their lives in enforced or voluntary exile. The "Laura" to whom Petrarch's sonnets were addressed was a lady of Avignon, France, whose memory he faithfully cherished for many years after she was carried off by the Black Death in 1348.

There is a charming story of the lad Petrarch poring over half-understood books of Latin rhetoric and poetry to the neglect of his study of the Roman law. His angry father, after throwing the forbidden

volumes into the fire, relented and allowed the boy to save his favorites, Vergil and Cicero, half-burned from the flames. Another story tells how Petrarch in later life carried everywhere with him a manuscript copy of Homer's poems, hoping always that he might find someone who could teach him enough Greek to explore that hidden world.

To only two men since his day—Erasmus in the 16th century and Voltaire in the 18th—has it been given to wield an intellectual empire over Europe so universal as was the lot of this poet-scholar of the early Renaissance.

To the studies of Petrarch and his followers, as distinguished from scholastic philosophy and theology, the name *litterae humaniores* ("more humane letters") was given. From this we derive our term "humanists" for such scholars. Classical literature not only supplied them with standards of better literary form. It disclosed "a new conception of life; a conception freer, larger, more rational, and more joyous than the medieval; one which gave unfettered scope to the play of the human feelings, to the sense of beauty, and to all the activities of the intellect."

Boccaccio, "Father of Italian Prose"

Today Petrarch's friend and fellow townsman, Giovanni Boccaccio (1313–1375), is chiefly known for his witty stories, entitled the 'Decameron', which won for him the name "father of Italian prose" (*see* Italian Literature). But even more important was his part in carrying on the revival of learning. For Boccaccio was the first Italian in seven centuries to learn to read classical Greek. In addition he wrote many Latin works of scholarship which aided in the search for and identification of the lost writings of ancient literature. Soon hundreds of eager scholars were engaged in the work of spreading abroad the "new learning," with all sorts of unsettling results.

Princes, churchmen, and nobles in Italy now gave to literature and art the attention which north of the Alps was bestowed upon the stables and kennels; and the place of the knight errant was taken by the wandering humanist, who sought manuscripts as the former had sought adventures.

And how much of real romance is packed into the history of that quest! Over 700 ancient Latin writers are known to us by name, but the works of less than a fifth of these have survived even in part. There are only 43 writers of whose works we possess the major portion.

That we have so much is due to the tireless efforts of men like Petrarch and Boccaccio; of Niccolo de' Niccoli, the collector whose 800 manuscripts form the nucleus of the Florentine library; of Poggio Bracciolini, who had great success in the monasteries of Switzerland; of Nicholas V, the first humanist pope; and of a host of others who, before the age of printing, rescued from the neglect of the Middle Ages the priceless works of the ancient Greek and Latin authors.

"The arts and the inventions, the knowledge and the books, which suddenly became vital at the time of the Renaissance," says the English author, J. A. Symonds, "had long lain neglected on the shores of the Dead Sea which we call the Middle Ages. It was not their discovery which caused the Renaissance; but it was the intellectual energy, the spontaneous outburst of intelligence, which enabled mankind at that moment to make use of them."

Two agencies chiefly helped to spread the Renaissance beyond the Alps, gave it a Christian instead of a pagan character, and made it a contributing factor to the religious Reformation. The invention of printing, about 1450, was one of these (*see* Printing); Erasmus of Rotterdam (1466?–1536) was the other.

Charles Reade's 'Cloister and the Hearth' tells the story—largely by means of Erasmus' own writings—of the unhappy parentage of this great Dutch scholar. Born an illegitimate child and thrust into a monastery while still a mere boy, he became by his brilliant talents the protege of princes and prelates. He spent his manhood in furthering the revival of Greek and Latin learning in France, England, Switzerland, and Germany—"wherever there were friends, books, and a printing press."

His 'Handbook of a Christian Soldier' was a manual of practical piety which ran through edition after edition. His 'Praise of Folly' (*Encomium Moriae*), written in England, while resting in the house of his friend Sir Thomas More after a visit to Italy, set all Europe to laughing at the hair-splitting subtleties of theologians, the slavish ceremonies of the monks, the ignorance and superstitions of the people, the luxury and neglect of duty by the heads of church and state. On the other hand his printed edition of the Greek New Testament (1516), and his editions of the writings of the early church fathers, laid the foundations for a sounder biblical theology.

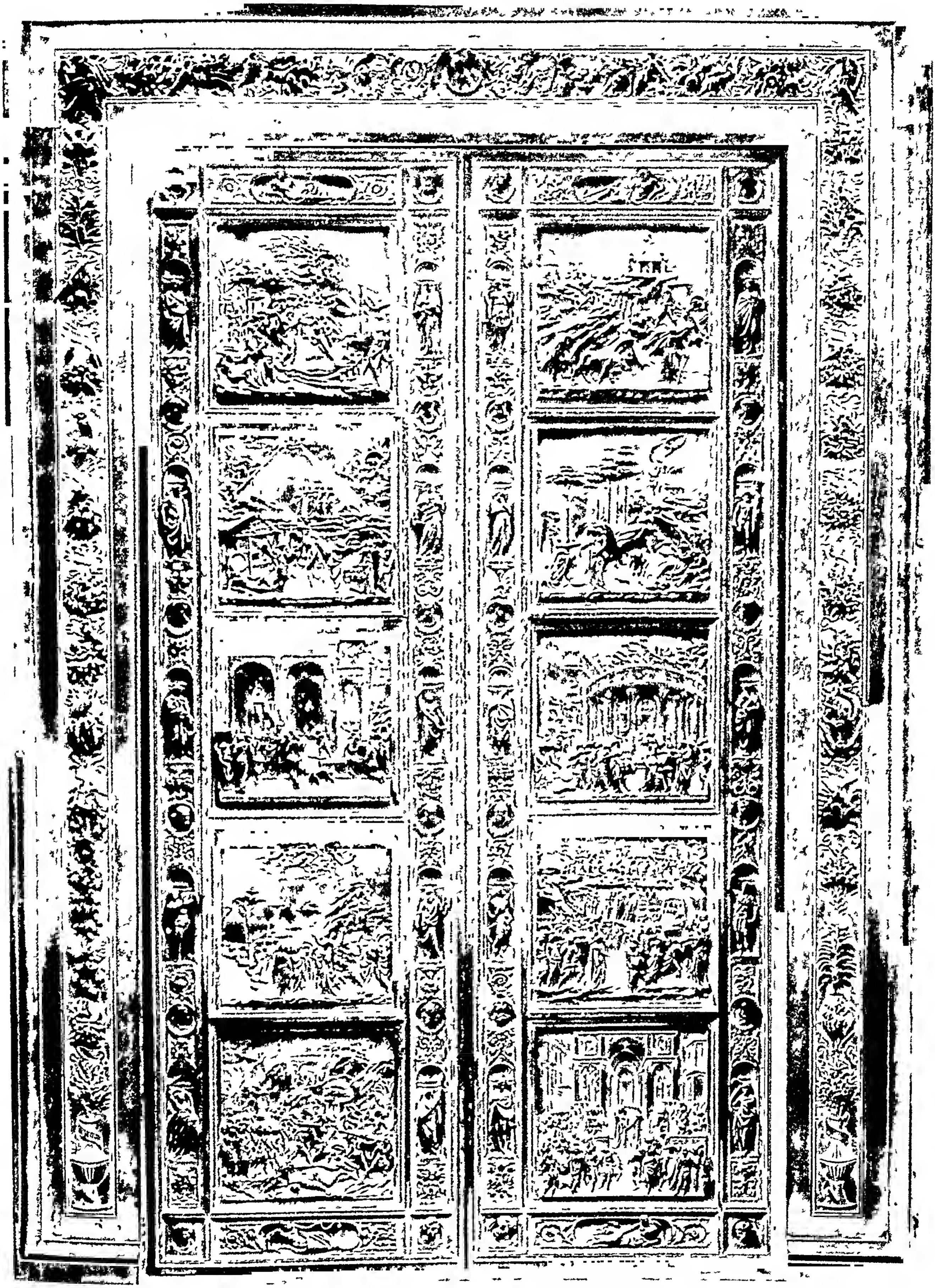
Scores of scholars north of the Alps worked to the same ends; and the newly founded German universities, and the magic art of printing, carried the seeds of this Christian revival of learning far and wide over western Europe.

Revival of the Fine Arts

Parallel to this awakening of the human intellect was a great development of the fine arts. After centuries of stiff symbolic representation, artists began again to study nature herself and to work from the living model. New ideas of grace, harmony, and beauty were gained from the sculpture and other artistic remains of classical Greece and Rome. Presently came the discovery of better technical methods of execution—of the laws of perspective and the process of painting in oils. The result was that the art of painting burst into a glory previously unknown, and sculpture and architecture rivaled the grandeur of the ancient days.

As in the revival of learning, Italy again led the way, though the countries beyond the Alps soon followed. The dawn of the new age came with the sculptors Nicholas, John, and Andrew of Pisa. Contemporary with them was Giotto of Florence (1266?–1337)—

THE MOST FAMOUS DOORS IN THE WORLD



The bronze doors, covered with gold leaf, made by Ghiberti for the Baptistery of Florence, are regarded as among the world's greatest masterpieces. The panels illustrate ten Old Testament stories.

sculptor, architect, painter, and friend of Dante. Ghiberti, Donatello, and Della Robbia—the latter the creator of the charming medallions of children in glazed terra cotta—continued the work in sculpture; Fra Filippo Lippi, Botticelli, Ghirlandaio, and Perugino in painting; and Brunelleschi and Bramante in architecture. The tumultuous exuberance of Gothic art gave way to the serene and rational beauty of the classic orders, the pointed arches to rounded Roman ones, the aspiration of vertical lines to the restful calm of the horizontal. St. Peter's in Rome sums up in itself the spirit of Renaissance architecture.

The full flowering of Renaissance art came in the late 15th and early 16th centuries, with Raphael, the prince of painters, Leonardo da Vinci, and Michelangelo, embodiments of supreme many-sided genius. With these flourished the lesser lights—Andrea del Sarto, "the faultless painter"; Correggio, who depicts Christian saints with pagan charm and beauty; Titian, the superb master of Venetian colorists; and Tintoretto, a master of technique.

ERASMUS OF ROTTERDAM

The profound scholar and witty satirist Desiderius Erasmus was the greatest figure of the Renaissance in the lands that lay north of the Alps. This splendid portrait of him by Hans Holbein hangs in the Louvre, Paris.

North of the Alps—in Flanders, Holland, and Germany—the chief names are the brothers Van Eyck, to whom is ascribed an important part in developing oil painting, Albrecht Dürer and Hans Holbein, each of whom is connected with the new art of printed engraving as well as painting. The greatest of northern painters—Rubens and Rembrandt—belong to the period following the Renaissance.

The Later Renaissance

In any great movement, sooner or later enthusiasm begins to wane. The study of Latin and Greek, which, to the humanists, was a method of getting at the kernel of classical culture, became formalized into an uninspiring routine discipline. Many writers became mere imitators of the ancients. Art degenerated into such extravagances as baroque sculpture and architecture. Individualism often became a mere cloak for unclassical lack of moderation and self-discipline. Rulers often adopted the view that the end justified the means, and the end was likely to be a selfish exercise of power. Such views are called Machiavellian, from Machiavelli of Florence (1469–1527), author of 'The Prince', a book on statecraft. All this and more may be said in criticism of the late Renaissance; yet, the inspiration derived from humanism has continued to our own time.

In the early modern age, the creative spirit found expression in many ways—in the writings of Rabelais, Cervantes, and Shakespeare; in the music of Palestrina; in the invention of the operatic form of music; in the perfection of the violin by the master-craftsmen of Cremona; in the introduction of three of the greatest inventions of all time—the compass, gunpowder, and the printing press; in the work of the scientists, such as Copernicus, Vesalius, and Galileo; in the formation of strong central governments; in the building of cities; in the reorganization of business; in the adventurous voyages of Diaz, Vasco da Gama, Columbus, and Magellan; and in the marvelous energy displayed by Europeans in carrying their civilization to all parts of the world.

Town Life Before the Renaissance

Greek and Roman civilization was a civilization of towns and city-states. The people of the Middle Ages were overwhelmingly agricultural. In a broad sense, the Renaissance included a revival of town life, with its diversified industries and interests, no less than a rebirth of ancient literature and art.

Long before the 14th century, towns flourished in nearly every section of Europe. They arose in various ways. The earliest towns were places of refuge and defense: the word "town" comes from the Anglo-Saxon *tun*, a fortified place. Castles, monasteries, cathedrals, and fortresses were sometimes located at the crossroads of leading highways, near well-protected harbors, or at a break in a stream. If a site combined the advantages of protection and of trade, a market or a fair was likely to be established there, and a town would grow up. Merchants of a particular town usually formed an association or "merchant gild." Traders and members of their families at these places often had leisure to manufacture goods, which they offered for sale at the markets. When they came to think of themselves more as craftsmen than as traders, they formed craft gilds, such as the gilds of "the butchers, the bakers, the candlestick makers," and many others. Gilds were partly social organizations, like the clubs and fraternities of today. Their main purposes were to protect their members from land-

lords and rival merchants and craftsmen of other towns, and to regulate the making and selling of goods so as to maintain standards and to prevent abuses. (*See* Guilds.)

Growth of Towns

Towns grew up very slowly. For defense they were surrounded by stone walls. Narrow streets wound around a hillside, or about a castle or cathedral, or along a shore line of a harbor. Upper stories of buildings were often built out over a street below, to save space, for space within the protecting wall was precious. Industrial life was conducted along very simple lines. A shoemaker, for example, bought his leather in the weekly market, took orders from his customers, and made the shoes and sold them in the front of his house, and used the rear or an upper floor as a dwelling.

In larger places, townsmen gradually secured privileges, such as the right to pay a town tax instead of rendering individual services to a lord, and the right to have their own town government. Most towns were little more than villages. As late as 1250, London probably had only about 25,000 people; the two towns next in size, York and Bristol, each about 10,000; and most of the towns of England, from 1,500 to 4,000. In places on the Continent, and especially in Italy, in southern France, on the Rhine River, and in parts of the Netherlands, towns were much larger and more influential than in England, but even in these regions, the great revival of town life and the general expansion of trade beyond local limits were distinctive features of the age of the Renaissance.

When merchants attempted to carry on trade beyond the interchange of goods between local villages, towns, and markets, they met many difficulties. Guilds, which were organized for purely local trade, were usually hostile to outsiders. Londoners, for example, were regarded as foreigners at Bristol. The disorder of the long-continued invasions was followed by almost constant fighting between the feudal lords. Rulers were interested not so much in encouraging trade as in exacting tolls and taxes. There were few good roads and bridges, and only a small number of lighthouses or other aids to navigation. Goods were carried mostly by pack-horse, sailboat, and rowboat. Geographical ideas were vague and commonly erroneous. Storms, floods, fires, pestilences, and other "acts of God" were dreaded less than the acts of "robber barons" and of pirates. There was no dependable system of money. Credit was little used, and weights and measures as well as coinages were matters of local arrangement. Added to all these difficulties, crude methods of production and transportation limited the available surplus of goods for sale.

Europeans Find Ways to Trade in Distant Lands

In view of these conditions, there was a remarkable growth of towns and expansion of trade in the 14th and 15th centuries. The first, or medieval, phase of this expansion was connected with the Crusades. Knowledge of new goods and of new opportunities for trade and adventure stimulated a keen desire that, in turn, resulted in the finding of methods to overcome obstacles in the way of distant trading. (*See* Crusades.)

Guilds and town markets were merely local. How did goods from one region find their way to other parts of Europe or to more distant countries? An old English law refers to "pedlars, tynkers, and petye chapmen." These men visited markets and fairs and went about the country in large numbers, selling such goods as "pynnes, poyntes, laces, gloves, knyves, glasses, and tapes." They were "a jovial race," seeking success "through fair speech and enticing words."

In addition to "petty chapmen," there were regular merchants and their agents, many of whom not only visited the principal fairs and towns in their own countries, but also bought and sold in the marts of distant places. They often acquired considerable wealth, became widely acquainted, and by interchange of ideas and customs built up a set of practises known as the "law merchant" for regulating trade throughout Europe. Fairs held once or twice a year sometimes attracted merchants from many different regions. Transactions at fairs as well as trade by sea came under the regulations of the law merchant.

Start of Banking Systems

Some of the wealthier merchants were also bankers. They loaned money to landlords and rulers as well as to business men, and found ways to overcome the medieval objections to interest, or usury. They bought and sold at a profit different kinds of coins—a business called "money changing." They came to be so well known not only at home but also in other parts of Europe that they often acted as agents in handling accounts as well as goods. If A in Germany owed B in Italy for a consignment of goods sent north, and if C in Italy owed D in Germany for goods sent south, credit arrangements resembling modern bills of exchange were handled by bankers such as the Fuggers of Augsburg or the Medici of Florence, so that it was not necessary to send much cash back and forth. The bankers introduced, in a crude form, the writing of insurance policies. Their notes and credit papers were so widely recognized that they circulated to some extent as money. Thus, in the early expansion of trade, were the beginnings of our financial system.

Merchants had little protection from robbers, pirates, and other hazards of travel. Partly for protection and partly for companionship, they traveled in groups, employed guards, and sent out their armed boats in fleets. Many associations or companies were formed for a single voyage or particular occasion. In some cases, permanent groups or corporations were formed. In England, for instance, the Merchants of the Staple handled staple goods, such as wool, tin, leather, and lead, and were required to ship them from certain "staple" towns in England to a "staple" town on the Continent. Later, the Company of Merchant Adventurers was formed to deal more largely in manufactured goods, especially woolens, which Englishmen were beginning to make for the markets in the 15th century.

These companies received charters of incorporation, with various rights and powers. They were "associated" or "regulated" companies. The members carried on trade on their own accounts, with the protection and the regulations of the company. First in Italy, and later in other countries, some of these groups became joint-stock companies. The selling of pieces of paper representing shares of ownership and interest in an enterprise has come to be the principal method of financing business undertakings.

In Venice and some other cities, ships were owned and operated by the town governments. These governments also sent out consuls, established trading centers, and made treaties. There were leagues of governments. Of these the most famous was the Hanseatic League of North German cities. It served in place of a strong central government such as existed in England. (*See* Hanseatic League.) In Western Europe, powerful central governments were growing up; and when trade shifted westward in the 16th century, not town but national governments formed the political basis for commercial and colonial expansion.

Europe Faces Westward

Trade expansion first extended merely to the exchange of goods between adjacent regions—for example, wool from England to Flanders and woolens from Flanders to England. By the 14th century, Europeans were trading indirectly with countries as far away as India, China, and the Spice Islands. Italians, especially Venetians, sent fleets to ports of the eastern Mediterranean. Here they secured spices, gems, drugs, silks, embroideries, and fine fabrics from age-old Oriental workshops. These goods, collected in Oriental markets, bazaars, and fairs, were carried westward by successive groups of merchants either overland in caravans or by sea to the Isthmus of Suez or partly by land and partly by water by way of the Persian Gulf and the Tigris-Euphrates river valleys.

In the 14th century, the writings of Ptolemy, the ancient geographer, had been recovered. Ptolemy had suggested that one would reach India by sailing westward. Columbus had a copy of Ptolemy's geography. Many other navigators believed that the earth was a sphere; and before Columbus tried to carry out his idea of sailing westward to India, the Portuguese took the lead in western explorations (*see* Henry the Navigator; America). Early in the 15th century, they occupied several of the western islands, advanced beyond the Sahara, and opened up the slave trade. They employed many Italians, who were skilled in shipbuilding, map making, the use of the compass, and the art of navigation. With the help of these Italians, they seemed on the point of breaking up the monopoly of the Italian cities in the Far Eastern trade, for they gradually extended their influence southward along the islands and the mainland till by 1488 Diaz had rounded the Cape of Good Hope. However, some explorers, including Columbus, still believed that the simplest way to reach India was by sailing directly westward. When Columbus returned from his first voyage of 1492, it was generally believed that he had discovered, not a new world, but a new route to the old world of eastern Asia. The Portuguese then redoubled their efforts, and in 1498 Vasco da Gama reached India by sailing around Africa.

The immediate results of the great discoveries included the breakdown of Italian and German trade; the transfer of trading centers, wealth, and power to the Atlantic seaboard; the rise of the Portuguese and Spanish empires; and the almost unbelievable stirring up of the sluggish minds and ambitions of Western Europeans. Out of the twofold stimulus of the recovery of ancient culture and the discovery of the nature and limits of the world's geography, came most of the distinctive ways of thought and of life that make our age different from earlier ages.

REFERENCE-OUTLINE FOR STUDY OF THE RENAISSANCE AND THE REFORMATION

THE RENAISSANCE

I. **Causes and beginnings:** influence of the Crusades R-107, M-238*e*, A-187, C-522, A-315; desire for eastern trade A-188, R-108; new inventions R-104, E-240, C-328, P-414*d*, G-234, G-232, C-427; growth of the creative impulse A-315. See also the Reference-Outlines for Middle Ages and World History

II. **The Renaissance in literature** R-103-4
   - A. **Causes and development in Italy**
     1. Early prosperity of Italian cities A-187, R-108, V-445, S-339
     2. Florence—center of culture F-147, M-163
     3. Rediscovery of classical literature A-187, R-103-4, E-249
     4. A new literary language F-147, I-259: Dante D-14*n*, R-103; Petrarch R-103-4, E-249; Boccaccio B-203, R-104
   - B. **North of the Alps:** Erasmus R-104, R-92; printing P-414*d* (Gutenberg G-234-5)
     1. In France F-301, F-287, M-366
     2. In England E-376*a*-377

III. **The Renaissance in the arts** R-104. For references to biographies and other information, see the Reference-Outlines for Architecture, Painting, and Sculpture
   - A. **Classic influence in Italy** R-103: architecture A-318; sculpture S-78*a-d*; painting P-25*c*-27*b*; church patronage in art J-364, L-170, M-163
   - B. **Great artists of the north:** Dürer D-164 and Holbein H-406, color pictures P-27*b*

IV. **Beginnings of modern science**
   - A. **Astronomy** C-328: Copernicus C-472, A-444; Galileo G-5, G-171, M-232, T-46; Kepler K-35
   - B. **Development of medicine through study of anatomy:** Vesalius A-239; Harvey A-239, B-210

V. **Explorations and discoveries—new ideas of geography** R-108, C-328: navigation A-188, N-79, C-427-8; commerce S-339, A-188, S-445. See also the Reference-Outlines for Spain and Portugal, Africa, Asia, United States History, and Canadian History

VI. **Economic and political changes:** town life R-107; financial system B-51, R-107, C-487; powerful central governments E-432

THE REFORMATION

I. Beginnings in Germany
 A. Background of the revolt R-91, C-302: Wycliffe W-314, picture R-91; Huss H-452; Erasmus R-92, R-104, picture R-106
 B. Reformation in Germany C-302, G-97: Luther L-352, R-91; Peace of Augsburg R-93
II. Catholic Spain tries to check the Reformation: Charles V C-189-90; Philip II P-191, S-321
 A. Reformation spreads during Spanish-French wars over Italy E-432: Francis I F-275
 B. Netherlands revolts N-120-1, W-139, P-191

Note: For the great military struggle at this time, see the section Thirty Years' War later in this outline

III. Calvinism and its allies C-49, picture R-92
 A. In Switzerland C-302, C-49; Zwingli Z-366
 B. Huguenots in France H-442, C-302-3, R-152: persecutions C-382, C-194; Edict of Nantes H-339
 C. In Scotland S-65: Knox K-63; Mary Stuart M-106-7
IV. Reformation in England E-364-5
 A. Henry VIII breaks with the Roman Catholic church H-338: Cardinal Wolsey W-182; Thomas More M-391
 B. Doctrinal changes and Catholic reaction C-303: Mary I (Bloody Mary) of England M-105
 C. England becomes the Protestant champion of Europe under Elizabeth I E-365, E-333: defeat of the Spanish Armada (1588) A-372, D-129, P-191

COUNTER-REFORMATION

I. Early reformers: Savonarola S-51; Ximines X-327
II. The Inquisition I-151: under Philip II S-321-2
III. Within the church R-93: Loyola L-338; Xavier X-327

THIRTY YEARS' WAR

I. The last great war of religion T-118-19: Gustavus Adolphus G-233, W-10; Cardinal Richelieu R-152
II. Results: religious T-119, E-432; devastation of Europe T-119; political adjustments E-432

Note: For the next great change in the history of western civilization, see the Reference-Outline for Industrial Revolution. For the intervening period of exploration and colonization, see the Reference-Outlines for World History, Europe, Asia, Africa, South America, United States History, Canadian History, and the principal countries of Western Europe

BIBLIOGRAPHY FOR RENAISSANCE AND REFORMATION

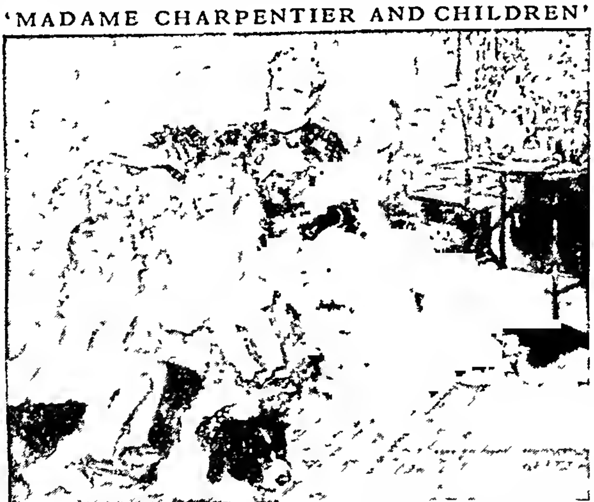
Benesch, Otto. Art of the Renaissance in Northern Europe (Harvard Univ. Press, 1945).
Burckhardt, J. C. Civilization of the Renaissance (Oxford, 1945).
Durant, W. J. The Renaissance (Simon & Schuster, 1953).
Evernden, Margery. Knight of Florence (Random, 1950).
Ferguson, W. K. The Renaissance (Holt, 1940).
Fosdick, H. E. Great Voices of the Reformation (Random, 1952).
Harsányi, Zsolt. Star-Gazer (Putnam, 1939).
Mills, Dorothy. Renaissance and Reformation Times (Putnam, 1939).
Sellery, G. C. The Renaissance (Univ. of Wisconsin Press, 1950).
Smith, Preserved. Age of the Reformation (Holt, 1920).

RENOIR (*rĕ-nwär'*), PIERRE AUGUSTE (1841–1919). In a house in southern France a crippled old man sat in bed with an easel propped before him. A nurse put a paint brush into his twisted, rheumatic hand. Painfully he dabbed at his palette. Then with sure even strokes he painted. This was how Renoir worked in his last ten years. Yet his paintings were as beautiful as those of his younger years.

Renoir was born in Limoges, France, Feb. 25, 1841, the son of a tailor. When he was four the family moved to Paris. There he sang in a choir directed by the composer Gounod. Gounod wanted him to study music. But the family was poor, and at 13 Auguste was earning his living painting flowers on china dishes. When machines replaced handwork, he decorated fans and window blinds. He saved enough to study art with Gleyre and at the École des Beaux-Arts.

In the 1870's Renoir was a leader in the Impressionist school (*see* Painting). Then he became dissatisfied with his work. In 1880 he gave up his studio in the artists' section of Paris and moved with his family into the suburbs. He also traveled to study older paintings in European galleries. Slowly his style changed to a more orderly, traditional method of composition. To learn more about the human figure and other forms, he studied sculpture.

'MADAME CHARPENTIER AND CHILDREN'



Renoir painted this lovely family group in 1878. He particularly liked to paint mothers and children.

Children appear often in Renoir's paintings. Among his favorite models were his three sons. Governesses and household servants also served as subjects. The family cook was hired more for her beautiful complexion than for her cooking. The texture and coloring of the flesh and hair in Renoir's paintings seem almost real. He was equally skillful in painting the color and texture of flowers. He would often see a bouquet arranged by his wife and paint it before the blooms faded.

Renoir was 58 when he suffered his first attack of rheumatism. Seeking a milder climate, the family moved to Cagnes in southern France. Renoir's infirmity grew until he was completely bedridden, but he continued to paint almost to the day of his death.

The ONCE POWERFUL *Tribe of* REPTILES

REPTILES. Everyone has seen a snake or tiny lizard slither off some woodland path. But if a person could put himself in time 100 million years ago, many of the reptiles would not run from him. Instead he would run from them. Modern reptiles, dangerous as some of them may be, are only the last weak remnant of a great and powerful tribe that once ruled the world.

Today reptiles are not important members of the animal kingdom. But scientists give them a most important middle place in the family tree of the vertebrates (animals with backbones). Above them are the two topmost branches, the birds and the mammals. Below them are the amphibians, including frogs, toads, newts, and salamanders. Scientists make this arrangement because they believe that reptiles were derived from some long-dead amphibian form, and that they in turn gave rise to birds and mammals.

What Is a Reptile?

Modern reptiles are found all over the world, except in the very cold regions. They are most numerous in the tropics. Many distinctive characteristics mark the reptiles off as a separate class of animals. The following are the most important. they are cold-blooded; they are fully adapted to life on land; they have a distinctive type of heart, and most of them have scales and many have claws.

On a warm day, a snake that has been basking in the sun wriggles away energetically when it is disturbed. But on a cold day, if any snakes are to be seen at all, they seem sluggish and sleepy. Like insects, reptiles depend almost entirely on the sun for their body heat and energy. They cannot produce heat in their bodies as birds and mammals can. This fact sharply separates the reptiles from these higher types of animals.

A typical amphibian, such as a frog, lays its eggs in the water. There the young hatch out and live for a while as tadpoles, breathing with gills. Only later do they develop lungs, come out on land, and breathe air. A typical reptile, on the other hand, lays its eggs on land. The eggs are specially formed so that they do not need watery surroundings. When the baby reptiles hatch, they have lungs and can breathe air immediately. Never at any time do they have gills. An amphibian can never live far from water. But many reptiles, such as rattlesnakes and horned "toads," can survive in the driest deserts.

A reptile's heart also makes it a more efficient type of animal than an amphibian. Frogs, for example, like all amphibians, have a three-chambered heart And dogs and chickens, like all mammals and birds, have four-chambered hearts. The four-chambered arrangement keeps pure arterial blood from mixing with impure venous blood.

The heart of a typical reptile such as a lizard is midway in form between these two kinds. It has two rear chambers (auricles) and has only one front chamber (ventricle), but a partition divides the ventricle almost completely in two. Thus the reptile's heart is almost as efficient as a mammal's or a bird's (*See also* Heart.)

Some amphibians and reptiles look very much like each other. Salamanders closely resemble certain kinds of lizards. But handling both animals reveals a significant difference. The amphibian has a smooth moist skin, while the reptile has a scaly covering. It is not "cold and slimy," as many people think except in a few water-dwelling species. The scaly skin of an ordinary land reptile feels hard and dry, and usually warm. The reptile (if it has legs at all) also has claws on its toes. The amphibian does not.

Kinds of Reptiles

All the reptiles, both living forms and extinct, make up the class *Reptilia*. There were once about 16 orders in this mighty class. But all reptiles now living fall into four orders, and one of these contains only one species. Scientific names of the orders are: *Chelonia* the turtles; *Squamata,* the lizards and snakes; *Crocodilia*, the crocodiles and related forms; and *Rhynchocephalia*, the tuatara.

The turtles split off early from the main stem of the reptile tribe. Like many other types of animals they specialized in defense. Their shells, developed from scales, make them now the most completely armored of the reptiles (*see* Turtle; Tortoise).

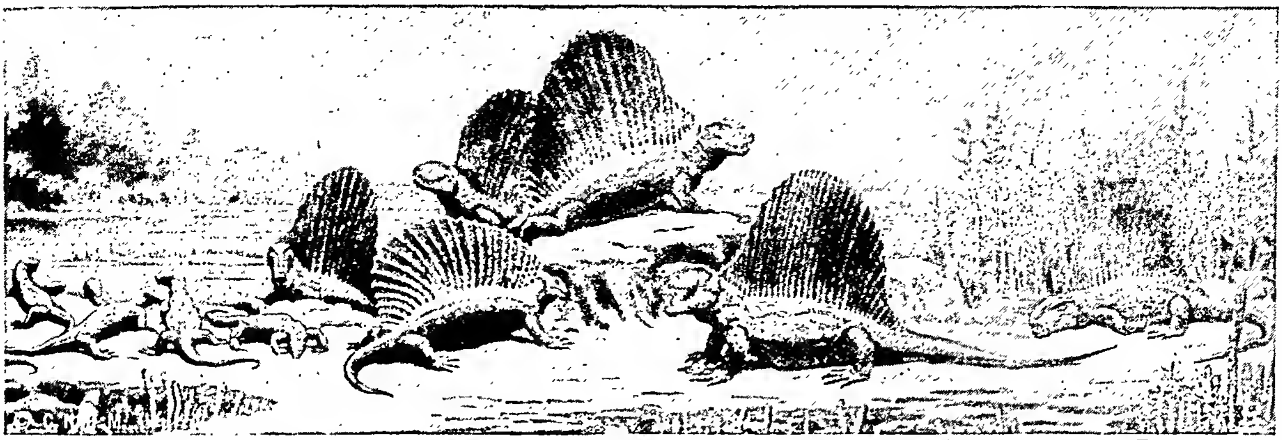
Lizards and snakes are the most numerous modern reptiles. Snakes evolved from a lizard stock which learned to get along without legs. But absence of legs does not alone distinguish snakes from lizards Some true lizards are legless, and some snakes have rudimentary legs inside their bodies (*see* Lizards; Snakes).

Crocodilians, the closest living relatives of the dinosaurs, are the largest modern reptiles Widely distributed in tropical regions, the

A CRAWLING, GRUNTING "LIVING FOSSIL"

This strange reptile, the tuatara of New Zealand, hunts in the dark. Now, dazzled by the sun, it is looking for a hole to hide in. It is about two feet long, olive in color with yellowish markings. At night it comes out of its burrow, grunting and croaking, to feed on insects, worms, and small fish.

NIGHTMARES OF THE DAYS WHEN REPTILES FIRST GREW GREAT



These grotesque fin-backed reptiles lived and died out in Permian times, long before the great dinosaurs appeared. The five creatures with the taller "sails" and savage teeth were the most fearsome flesh eaters of their time; the smaller finback was a plant eater. Scientists do not know why these species developed their weird fins. The paintings of ancient reptiles in this article are by Charles R. Knight. They are reproduced by courtesy of the Chicago Natural History Museum, which holds the copyright.

alligators, crocodiles, and gavials are all carnivorous water dwellers (*see* Crocodile; Alligator).

The tuatara (*Sphenodon*) lives only on small islands near the coast of New Zealand. It looks much like an iguana, but features of its skull distinguish it sharply from the lizards. Almost identical creatures lived when the dinosaurs, described later in this article, walked the earth. Tuatara seems like a lone survivor from those times. (For other articles on reptiles, *see* Reference-Outline for Zoölogy.)

How Reptiles Ruled the Earth in Mesozoic Times

IMAGINE a reptile longer than a railroad car, or one so tall he could poke his nose into a third-story window. Imagine also teeth six inches long set in a yawning mouth half as large as a house door. Fortunately for us we shall never meet creatures like these. They are not alive today. They did live long ago, however, and they are known as dinosaurs.

While these great reptiles lived, they held undisputed sway over the living world. The biggest dinosaurs were the largest animals that ever walked the earth. The only larger creatures are modern sea-dwelling whales. Some lived in swamps and ate the lush plant growth. Ferocious meat-eating types preyed on the plant eaters. These hunting dinosaurs had the power of a heavy truck in motion and teeth like a mouthful of daggers.

When geologists say dinosaurs lived long ago, they mean many millions of years ago. They believe that dinosaurs came into being about 180 million years ago, and died out about 60 million years ago. Of course this was long before human beings appeared upon the earth. Also there were no animals like dogs, rabbits, horses, monkeys, or elephants. But there were many other kinds of reptiles besides the dinosaurs. They lived on land and in the water. So plentiful and so powerful were the reptiles of that time that it is called the Era of Reptiles. Its scientific name is the Mesozoic Era.

WHEN REPTILES TOOK TO THE AIR

Two groups of reptiles adapted themselves to life in the air, perhaps at nearly the same time. The *pterosaurs*, shown in the upper part of this picture, remained true reptiles. The other group, not closely related, became birds. The feathered creatures here are primitive birds of Jurassic times.

We know about these creatures only from fossils—remains which they left in the earth (*see* Fossils). These are of different sorts. The commonest consists of petrified remains of the hard parts of their bodies—bones, teeth, and claws. From these, skeletons can be reconstructed and they tell how the body was built. When petrified tendons and skin are found, we learn even more about the animals. Other fossils are trails or footprints, made in wet sand or mud that hardened into stone. These show how the animals walked, whether on two

TWO WAYS OF LIFE IN MESOZOIC SEAS

These Jurassic creatures show how prehistoric reptiles adapted themselves to life in the sea in two different ways. The plesiosaurs (left) developed flattened bodies and snakelike necks. They paddled about on the surface, darting their heads down to seize fish. The fast swimming *ichthyosaurs* (right) looked much like modern porpoises. Doubtless their habits were similar

legs or all four. The rarest of all reptilian fossils are dinosaur eggs. Most of them have been found in Asia. Some of these even contain the skeletons of tiny dinosaurs. They had been almost ready to hatch but were smothered when sand covered the nests.

The Earliest Reptiles

Dinosaurs were reptiles, but not the earliest. The first appeared in the Coal Age (in geology, the Carboniferous, or Mississippian and Pennsylvanian). In those days the largest land animals were amphibians, ancient relatives of the salamander. Their eggs were laid in water, and their young ones started life as tadpoles that breathed with gills.

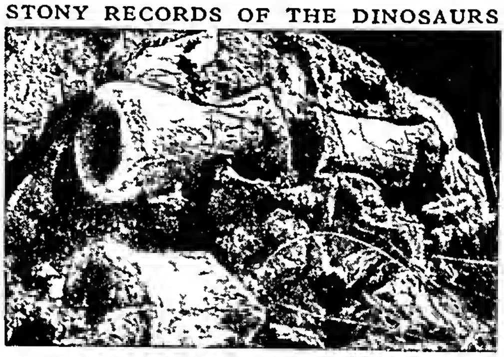
The first reptiles looked like amphibians, but their eggs could hatch on land. The young ones had legs and lungs, and could breathe air. They walked on damp ground in forests and probably ate insects.

During the Permian period reptiles became larger and stronger. Some looked like big lizards and others like turtles. There were also plump creatures with short tails, thick legs, and large heads. Some had long teeth, some had short ones, and others had no teeth at all. They ate plants, nipping them off with curved bony beaks. Strangest of all were the fin-backed reptiles (*pelycosaurs*), five to seven feet long. Growing from their backs were weird spiny "sails" like the dorsal fin of a sailfish.

How the Reptiles Branched Out

Finbacks and most of their neighbors died out before the Mesozoic Era began. Big-bodied reptiles still were common, however, especially in Africa and Europe. There were also armored reptiles with spines on their shoulders and others that looked like crocodiles. They were not crocodiles, however, for their nostrils were near their eyes, not on their snouts.

STONY RECORDS OF THE DINOSAURS



Fossils tell us all we shall ever know about ancient reptiles. At the top are the petrified tail bones of a dinosaur still imbedded in native rock. At the bottom is a dinosaur skull partially freed from its rocky bed.

Two groups of reptiles were extremely important because of their descendants. One consisted of short-legged creatures with large heads, the mammal-like *therapsid* reptiles. When they opened their mouths they showed three kinds of teeth—one for biting, one for slashing, and one for chewing. Such teeth, as well as bones in the skull, show that these reptiles were almost mammals. Some of their descendants did become mammals during the first (Triassic) period of the Era of Reptiles.

The other important group resembled lizards two or three feet long, but they walked upon their hind legs. Scientists call them *thecodonts*, from Greek words referring to their teeth, which were set in sockets. These creatures gave rise to many new types in the following (Mesozoic) era. Some were true reptiles with wings. One group developed feathers and warm blood and they became the first birds Other types included crocodiles and the first dinosaurs. All these types together proved efficient enough to dominate life on the earth. Hence they are often called the "Ruling Reptiles."

Dinosaur Giants of the Era of Reptiles

The first dinosaurs looked very much like their ancestors. They were slender reptiles about as large

PREHISTORIC REPTILE MONARCHS OF SEA AND AIR

Of the three reptiles shown here, only the giant sea turtle (right) resembles any modern form. The huge sea-going lizard (*mosasaur*) grew to be 30 feet long. The flying reptile Pteranodon was the largest scientists know of. Its wing span was 27 feet. These reptiles lived in and around a shallow sea that lay in the Mississippi Valley during the Chalk Age (Cretaceous times).

as a turkey, and they walked upon their hind legs. Some kinds remained small, but others grew heavier and longer. Before the end of the Triassic period, many dinosaurs were six to eight feet long. A few were twenty feet long and weighed as much as an elephant. They had small heads and short blunt teeth good only for eating plants. They lived in low, swampy places where they walked usually on their hind legs.

The second period in the Era of Reptiles is known as the Jurassic. During this period, some plant-eating dinosaurs became so large that even four sturdy legs would not support them on land. They had to spend most of their lives in rivers and swamps, where water could float part of their weight.

One of these Jurassic giants was Brontosaurus. (The name means "thunder lizard.") Brontosaurus was 70 to 80 feet long and weighed about 38 tons. Its head was small, its neck was long, and the last eight or ten feet of its tail were almost as thin as a whiplash. Its blunt feet had huge claws, three on each hind foot, but only one on each forefoot.

The swamps had other huge plant eaters. One known as Diplodocus had a long, slender neck and a still longer tail. Brachiosaurus, largest of all, must have weighed 50 tons. It had a short tail and long forelegs, unlike the others, and a tremendously long neck.

Various characteristics helped these dinosaurs live easily in water. Their leg bones were thick and solid, making good weights when they waded against swift currents. Their backbones, however, were hollowed out and had crossbars that gave strength without great weight. Thus the creatures could raise their long necks and move their very long tails. The nostrils of these dinosaurs were placed higher than their eyes. In this way they could breathe in water that covered all but the very tops of their heads.

While Brontosaurus and his relatives waded, dinosaurs of other kinds walked about on land. One called Stegosaurus was 20 feet long and 10 feet high, with two rows of bony plates on its back and spikes along its tail. There also were slender creatures four to six feet long, with long legs that were good for running and with tails that balanced their bodies. One of these, called Allosaurus, was 34 feet long. It had sharp teeth and powerful claws and it fed upon Brontosaurus and other peaceful plant eaters. This is proved by fossil Allosaurus teeth among broken, deeply scratched bones of Brontosaurus.

Flying and Swimming Reptiles

Other reptiles besides dinosaurs became common in Jurassic times. Strangest of all were the *pterosaurs*, whose name means "winged lizards." They had large heads, goggle eyes, sharp teeth, and skin-covered wings. The wings were supported by arms and extremely long, slender "little fingers." Most pterosaurs probably lived near the seashore, roosting in trees or on cliffs. When day came, they soared over the water, swooping down to catch fish for food. One of the smaller pterosaurs is known as the *pterodactyl*.

Fish-lizards (*ichthyosaurs*) were reptiles with shark-like bodies, flippers, and large fleshy fins. They appeared in the sea during Triassic times. Some kinds became 25 to 30 feet long, but most Jurassic ichthyosaurs were smaller. They spent their whole lives in the sea. There the young ones hatched from eggs that were kept inside the mother's body instead of being laid. The fish-lizards ate true fish, other reptiles, and creatures that looked like squids.

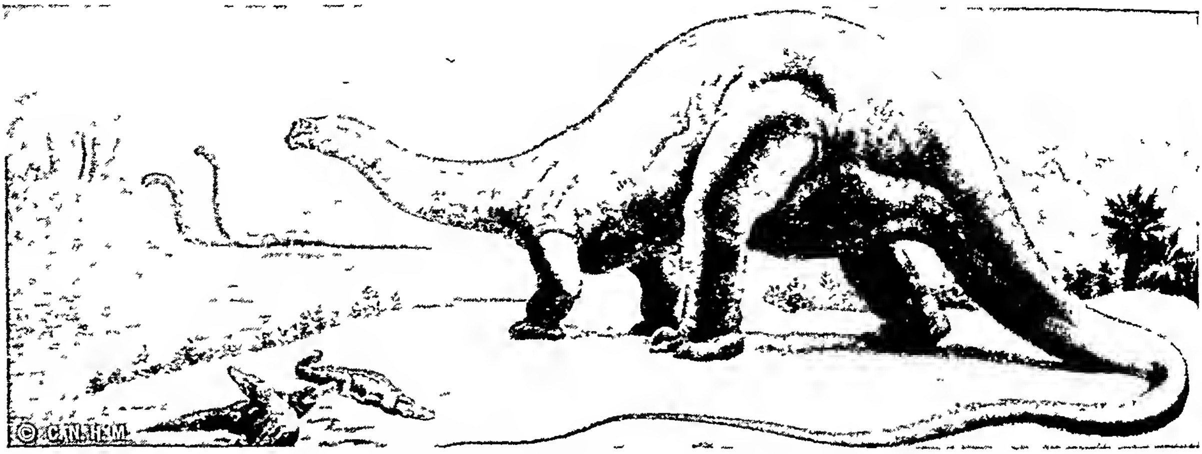
Other sea-dwelling reptiles called *plesiosaurs* had very broad bodies, long necks, and long tails. They swam swiftly by means of legs that had turned into powerful paddles. Their necks could dart from side to side, catching fish and small reptiles for food.

Development of birds from certain Triassic reptiles took longer than the change to dinosaurs, for the first birds did not appear until late in Jurassic times. They were creatures about the size of a crow, with long bony tails, three toes on each wing, and sharp little teeth in their jaws. In fact, they were built like small reptiles, but impressions of feathers prove that they were birds.

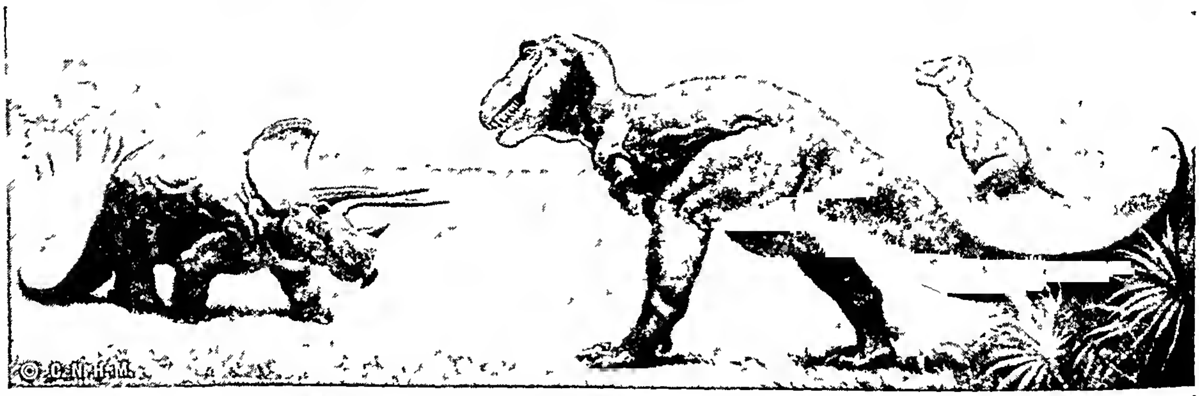
End of the Era of Reptiles

The last part of the Era of Reptiles is known as the Chalk Age (Cretaceous). Most of the huge swamp-

GIANT PLANT EATERS AND A GIANT HUNTER



Huge stupid Brontosaurus spent most of its time half submerged in water munching the tropical vegetation of the Jurassic Era. The picture shows it on land, where its feet and tail can be seen. In the left foreground are three ancestors of the crocodile.



Plant-eating Triceratops (left) and its bloodthirsty enemy, Tyrannosaurus (right) lived many millions of years later than Brontosaurus. Tyrannosaurus was the most fearsome hunter of any age. Triceratops was considerably more gentle than it looks.

dwelling dinosaurs died out before it began, but some species at least 35 feet long still lived in South America, Asia, and other parts of the world. Allosaurus also was gone, but a new group of meat eaters became even larger and more savage. The biggest, Tyrannosaurus, was a giant 47 feet long and 18 to 20 feet in height. His mouth was set with six-inch teeth that looked almost like daggers.

Other meat eating dinosaurs lost their teeth and developed horny beaks. They also became so slender that they must have looked like long-tailed ostriches with bare, wrinkled skin. In fact, the name they have been given, Struthiomimus, means "ostrich mimics."

The earlier plate-backed dinosaurs had died out, but some distant relatives grew thick coats of bony armor and massive, bony clubs on their tails. Another group developed ducklike bills and as many as 2,000 teeth; but they were harmless plant eaters. They lived in large swamps where they could find tender food and escape savage hunters such as Tyrannosaurus.

While duckbills waded in swamps, horned dinosaurs of various kinds lived on higher land. Their ancestors were creatures about six feet long, with hooked beaks and bony frills that covered their necks. As millions of years went by, however, the horned dino-

weighing six to ten tons. The best known, Triceratops, had a beak, three horns, and a bony frill that reached almost to its shoulders.

Other Chalk Age reptiles were as abundant and as strange as the dinosaurs. There were turtles weighing as much as a ton, plesiosaurs 40 feet long, and flying reptiles with wings that spread as much as 27 feet. The fish-lizards were dying out, but their place was taken by reptiles called *mosasaurs*. Mosasaurs had flippers, long bodies and tails, and sharp teeth in jaws that would open widely. Some were 35 feet long, and others may have been 50.

As the Chalk Age drew to a close, shallow seas began to disappear. Swamps turned into lowlands and then were forced upward into mountains. The dinosaurs began to die out. With them vanished the plesiosaurs, flying reptiles, mosasaurs, and the huge marine turtles. Other turtles kept on living, however, and so did crocodiles, lizards, and creatures that were turning into snakes. These survivors spread over the earth during the next era, which we often call the Era of Mammals. Their descendants became the reptiles found on the earth today.

Why Did Ancient Reptiles Die Out?

Why did so many of these Mesozoic reptiles become

more than one answer. One explanation for extinction is failure to meet competition. Fish-lizards, for example, were abundant before the Chalk Age began. Then the mosasaurs appeared, and the fish-lizards rapidly died out. Perhaps mosasaurs captured their food and preyed on young fish-lizards, thus causing their extinction. But this cannot be proved, nor does it explain why fish-lizards grew scarce long before mosasaurs became common.

It has also been said that dinosaurs died out because they were stupid. One dinosaur 20 feet long had a brain weighing less than three ounces and giants such as Brachiosaurus were not much better off. The huge creatures could not think with such brains; some, at least, controlled their bodies from swellings on the spinal cord. Still, countless creatures live without thinking, and gigantic dinosaurs did very well for several million years.

It has been suggested that disease might have destroyed these reptiles. Some of them did have diseases; the results can be studied in fossils. There is no evidence, however, that bacterial or other epidemic diseases ever caused vast numbers to die.

Another explanation blames the extinction of reptiles upon racial old age. In time the aging groups became weak or developed disorders in the glands that determine size, thickness of bones, and other characters. Extinction followed.

This theory has been popular but is very difficult to prove. Moreover, it hardly seems probable that several groups of dinosaurs, plesiosaurs, turtles and other reptiles grew old together at the end of the Era of Reptiles.

Most important of all is the theory that changes in the earth and its climate caused many ancient reptiles to die out. Such a change came at the end of Jurassic times, when swamps dried up, lowlands became mountains, and vast quantities of lava erupted. These changes undoubtedly robbed many dinosaurs of places to wade and feed. Since they could not live on dry land, they became extinct.

Then came the long, almost tropical Chalk Age, or Cretaceous Period. Reptiles became more abundant than ever on land, in swamps, and in shallow seas. For more than 50 million years they prospered. Then the period came to an end as lands all over the earth became uplifted. The seas disappeared, swamps became uplands, and prairies turned into mountains. Climates became seasonal, shifting from summer heat to frost and snow in winter. Most reptiles could not fit themselves to these changes, and all that could not do so died out.

MOST "BRAINLESS" OF THE DINOSAURS

© C. N. H. M.

Stegosaurus, a Jurassic plant-eating dinosaur, is famous for its queer platelike armor and for its brain, no bigger than a walnut. Probably the powerful spiked tail was more helpful to this sluggish animal than its elaborate armor or its tiny brain.

WHY DID HE HAVE A DUCK'S BILL?

© C. N. H. M.

The duckbilled dinosaur shown here stalking across a Cretaceous landscape is known as Trachodon. It probably used its odd bill in the same way a duck does—rooting for food in shallow water. The birdlike dinosaur in the far distance is Struthiomimus, the ostrich mimic.

This is a general explanation, and it probably is the best one. But it does not explain all the known facts. Scientists *still have a great deal to learn* about the lives and careers of these ancient reptiles before their disappearance can be satisfactorily explained.

Groups and Orders of Dinosaurs

Probably the most fascinating of all these extinct reptiles were the many kinds of dinosaurs, large and small. At first acquaintance, the wealth of types and wide variety of habits may seem confusing; but scientists believe that all of them can be classified into two large groups and six subgroups.

The large groups are distinguished by the structure of the pelvic girdle (hips) where the backbone, hind legs, and tail were attached. In one group, called *Saurischia* ("lizard hips"), the structure resembled that found in lizards. In the other, called *Ornithischia* ("bird hips"), the structure was much like that found in modern birds. The subgroups within these larger ones are as follows:

Order Saurischia ("lizard hips"). Suborders:

Meat eaters—all walked or ran on hind feet. Early types small (Triassic times); later, included giants such as Tyrannosaurus. Others grew slender and replaced teeth with beaks—among them, the "ostrich mimic" of the Chalk Age.

Large swamp dwellers—Walked on two feet in Triassic times; later became largest land animals on record and waded in swamps on four feet.

Order Ornithischia ("bird hips"). Suborders:

Earlier armored back—slow-moving plant eaters; backs covered with bony plates; walked on four feet. A few small teeth in scaly or horny jaws.

Later armored backs—broad, flat bodies covered with bony armor. Four-footed plant eaters; small teeth or none. Lived in the Chalk Age, long after the earlier armored backs had died out.

Duckbills and their relatives—swamp waders; thin teeth packed into a solid mass. Some had queer round heads of almost solid bone.

Horned and bony frilled types—four-footed plant eaters with teeth and powerful beaks.

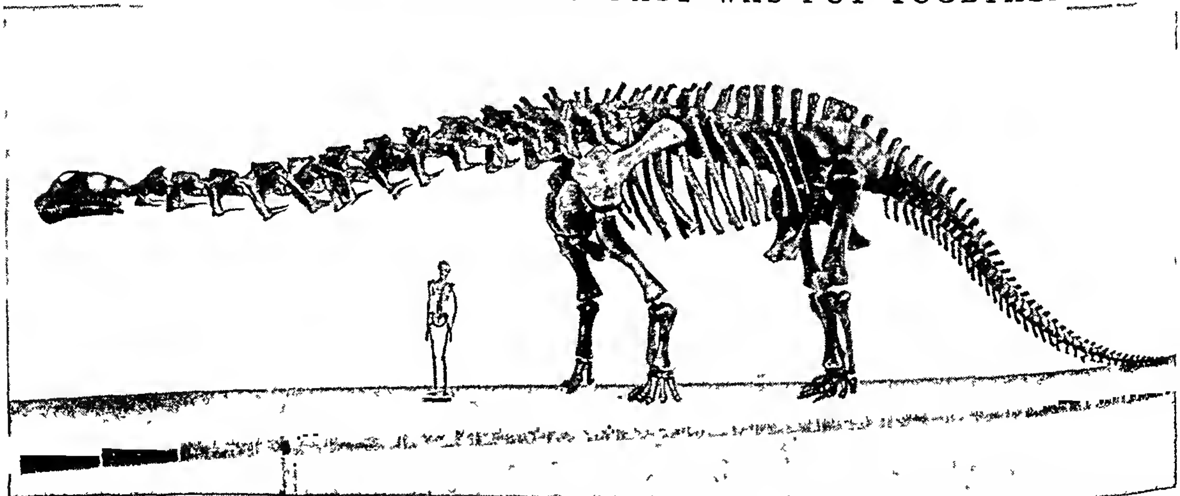
RESINS. When their bark is injured, many trees exude a sticky substance which hardens into a *protective coating*. *These* substances are the principal sources of natural *resins*. The most common pure resin is called *rosin*. It is a by-product of distilling turpentine from the sap of various pine trees (*see* Turpentine). Its biggest commercial use is in the paper industry. It is also used in paints and varnishes and for making laundry soap. Rubbed on the hair of a violin bow, the soles of a boxer's shoes, or the palm of a baseball pitcher's hand, it helps to produce friction.

Resins often contain gum (*see* Gums and Resins) One useful gum-resin is the vile-smelling *asafetida* used in medicine. It comes from various plants in western Asia. Another is *gamboge*, the dried, milky juice from the roots of certain plants in Cochin-China and Siam. It is used as a yellow pigment and sometimes in medicine. *Myrrh* is a fragrant gum-resin from several plants in Arabia and Ethiopia. It is used in medicine and in making incense and perfumery. *Dammar* resins from coniferous trees in India, New Zealand, Australia, and the East Indies are widely used in making varnish.

So-called "fossil" resins are found in the ground Amber is the most familiar of these (*see* Amber). Commercial fossil resin occurs mostly in coal beds where it was formed from the sap of prehistoric trees. Large deposits exist in Asia and the western United States. It is used in the same ways as ordinary resins

Synthetic resins resemble natural resins in their properties but differ from them chemically. One type of plastic, called pulp-resin, is composed of wood or cotton powder combined with a synthetic resin. These substances are molded under high pressure to form serving trays, plates, and many other lightweight articles. Textiles impregnated with certain synthetic resins are highly resistant to water, acids, and staining liquids like ink. (*See also* Plastics.)

HOW A MONSTER OF THE PAST WAS PUT TOGETHER



Nature provided Brontosaurus with a wonderful framework to support its vast bulk. The great leg bones were as thick and strong as tree trunks and the long spinal column is a marvel of engineering construction, combining strength and lightness. The huge size of this giant reptile may be judged from the skeleton of a human being mounted beneath it.

BREATHING, *the Mainstay of* ALL LIFE

RESPIRATION. All living things need oxygen just as much as they need food. Without oxygen, the food they take in would be useless to them and they would die. With oxygen, they are able to burn the carbon in their food, and the heat of the burning yields the energy that gives them the power to grow and move. In the burning, the oxygen combines with the carbon and forms carbon dioxide as a waste. The way living things get oxygen, use it, and get rid of carbon dioxide is the story of respiration.

HOW A FISH BREATHES

Water is drawn into the mouth and forced through the gill fringes shown above, which absorb the dissolved oxygen; then it passes out again through the gill slit.

The tiny one-celled animals and plants (like amoebas and bacteria) simply take oxygen in through cell walls and expel carbon dioxide in the same way. Among the larger living things the methods of respiration differ widely. Trees breathe through tiny holes in their leaves (*see* Plant Life). Insects breathe through fine tubes in the joints of their abdomens (*see* Insects). Earthworms breathe through their skins. Fish breathe through gills (*see* Fish). Reptiles, birds, and mammals breathe through lungs (*see* Lungs). Amphibians, such as the frog and the salamander, breathe through gills in their larval or tadpole stage and through lungs in adult life (*see* Frog; Salamander).

Most living things get their oxygen from the air. Some, which are cut off from the air, get their oxygen out of other substances. The yeast cell, buried in bread dough or in a fermenting liquid, breaks up the sugars or starches that surround it to get the oxygen it needs. The carbon dioxide given off by the "breathing" yeast causes the bubbles we see in fermenting liquids (*see* Yeast).

The larger living things need a transportation system to carry the oxygen to every one of their cells and to carry the carbon dioxide away. In plants, this is done by the sap. In the higher animals, the oxygen and the carbon dioxide are circulated by the blood (*see* Blood; Heart).

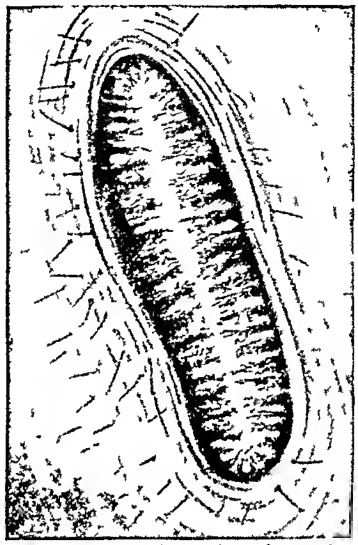
Man's Breathing Habits

We breathe by first taking air into the lungs (*inspiration*) and then expelling it from them (*expiration*). These two acts make up a *breath.*

An adult normally takes about 16 breaths a minute when awake and about 6 to 8 when asleep. But under stress, he may take as many as a hundred a minute. In a normal breath the average man takes in about one pint of air or approximately 30 cubic inches. The most he can inhale in one breath is about seven pints. No matter how hard he blows his breath out, he cannot empty his lungs. They will still contain about one quart of air.

After taking a single deep inspiration, the average person may not be able to hold his breath for more than 30 to 60 seconds. But if he carries on deep, forced breathing for a minute or two beforehand, he can increase the span. Before diving equipment came into general use, pearl and sponge divers often stayed under water four minutes or more.

A SIMPLE AIR HOLE



This is the "spiracle" or breathing pore of a silkworm. It leads into the air tubes that take the place of the gills of fish or the lungs of warm-blooded animals.

The Machinery of Breathing

To understand the machinery of breathing, we must know something about the airtight "box" called the chest cavity. The top and sides of the box are formed by the ribs and attached muscles; the bottom, by the dome-shaped muscular partition called the diaphragm (*see* Diaphragm). Inside the box lie the two lungs and the heart. The only openings are those through which pass the blood vessels, nerve cables, and windpipe. A partition running from front to back surrounds the heart and divides the lungs from one another. Each lung completely fills its compartment.

This entire box can expand or contract, somewhat like an accordion. This is accomplished in two ways. The rib muscles can pull the ribs up and outward or let them move down and inward. The diaphragm, in turn, can rise or fall.

When we breathe in, the rib muscles elevate the ribs and the diaphragm pushes downward. So the chest cavity grows larger. Immediately the air pressure in the lungs is reduced, and air flows into them.

When we breathe out, the rib muscles and the diaphragm relax and the chest cavity grows smaller. The lungs, which have been stretched by the incoming air, now contract elastically and grow smaller with the chest cavity. Thus air is forced out of the lungs.

The nose filters, moistens, and warms the incoming air to condition it for the delicate membranes of the lungs. Bristle hairs in the nostrils and sticky mucus

on the nasal membranes intercept particles of dust from the air. On the nasal membranes, tiny hairs called *cilia* beat outward ceaselessly and whip countless particles of dust back toward the nostrils.

What Happens to the Oxygen

Breathing is only the beginning of our story of respiration. Let us see what happens to the oxygen after it has entered the lungs with a breath of air.

The article on Lungs tells how oxygen passes from the air sacs into the blood stream. The article on Blood tells how the red corpuscles carry oxygen in a loose union with the chemical compound hemoglobin, throughout the body. Wherever working cells have thrown off waste products, the oxygen combines with carbon in the waste and forms carbon dioxide. The process releases energy, which rebuilds material for use by the cells. This is often compared to the process of obtaining energy by burning fuel.

The actual process is indirect and somewhat complicated. When a muscle cell does work, it obtains the necessary energy by uniting blood sugar or glycogen ($C_6H_{10}O_5$) with water (H_2O). This forms lactic acid ($C_3H_6O_3$). The oxygen in the blood reacts with some of the lactic acid to form carbon dioxide (CO_2) and water. The reaction releases energy enough to turn the rest of the lactic acid back to glycogen for reuse by the muscle cells. These reactions are controlled by enzymes or catalysts. Among these are B-complex vitamins (*see* Vitamins).

During the second World War, scientists learned how to imitate the action of hemoglobin with chemicals called *chelates*. These chemicals absorb oxygen from air, just as hemoglobin does in the lungs. When heated the chelate releases the pure oxygen. This process was used in remote places to obtain oxygen for various other purposes.

What Happens to the Carbon Dioxide

After carbon dioxide is formed, the blood stream carries it to the lungs. There part of it passes out through the air sacs as waste. The rest stays in the blood and helps to control our breathing.

This help is provided in the *respiration center*, a cluster of nerve cells in the medulla oblongata at the base of the brain (*see* Brain; Nerves). The work of the carbon dioxide, passing through the respiratory center with the blood stream, is to stimulate the nerve cells located there so that they send out a constant stream of nerve impulses. These travel to the rib muscles and the diaphragm, stimulating them to work.

Increase the carbon dioxide in the blood ever so little, and the respiratory center sends out stronger nerve currents so that we breathe more rapidly and deeply. Decrease the carbon dioxide, and our breathing automatically slows down.

During severe exercise, the hard-working muscle cells give off large amounts of carbon dioxide into the blood, and we breathe very rapidly. Even *after* a race, an athlete continues to breathe rapidly for some time until the amount of carbon dioxide in his blood is reduced to normal.

How the Nerves Change Our Breathing

The respiratory center is connected with nearly all the sensory nerves of the body. Hence any stimulation of these nerves can change our breathing. A sharp pain makes us catch our breath. The act of swallowing stimulates a nerve in the back of the mouth which sends a message to the respiratory center; breathing stops for a moment so food won't get drawn into the windpipe. Irritation of the throat makes us cough. Irritation of the nasal passages makes us sneeze. Yawning, sighing, laughing, sobbing, and hiccoughing—all these involve changes in our normal breathing rhythm stimulated by nerve messages transmitted through the breathing center.

Our various acts of breathing are essentially reflex or automatic (*see* Reflexes). But often the conscious centers of the brain may "order" the respiratory center to change our breathing, as when we take deep breathing exercises or cut off a sneeze before it can disturb our neighbors.

Valuable "By-products" of Breathing

Breathing serves us in a number of special ways. For example, we owe our voices to breathing. The air we breathe out vibrates our vocal cords to produce the sounds of talking, singing, and laughter (*see* Voice). Also the movements of breathing help to circulate the lymph and the blood (*see* Blood).

Physicians often study a patient's breathing before making diagnoses. The rate of breathing, under controlled conditions, may disclose facts about the state of the heart and lungs. Listening through a stethoscope to the various sounds of breathing may reveal the presence of respiratory disorders such as pleurisy, bronchitis, pneumonia, or tuberculosis.

A test very commonly used in a general diagnosis is called the *basal metabolism test*. This is given in the following way: The patient, while completely at rest, breathes in and out through the tubes of an apparatus that measures exactly how much oxygen he takes in and how much carbon dioxide he exhales in a given time. From this can be determined the rate at which the patient regularly burns up his body fuels. The physician then compares the patient's rate with the normal rate as shown on charts. A rate above normal may indicate an overactive thyroid gland, for this gland stimulates the oxidation processes. A rate below normal may indicate an underactive thyroid (*see* Hormone).

Artificial Respiration

A person whose breathing has completely stopped as a result of drowning, electric shock, or certain kinds of poisoning can sometimes be made to breathe again by administering *artificial respiration*. Several kinds of mechanical resuscitators are manufactured. If one of these is not available, artificial respiration can be applied by hand, as pictured in the article on First Aid. Infantile paralysis sometimes impairs the nerves that activate the muscles used for breathing, and such a patient may die from lack of air. He can be kept breathing by placing him in a mechanical respirator called an "iron lung." (For facts about the effect on health of the kind of air we breathe, *see* the article on Health.)

"THE MIDNIGHT RIDE OF PAUL REVERE"

A. L. Ripley has painted the exciting midnight arrival of Paul Revere in Lexington. Starting at ten o'clock, the courier has galloped 20 miles from Charlestown to warn the Middlesex countryside that 1,000 British redcoats are coming.

REVERE, PAUL (1735–1818). On the night of April 18, 1775, Paul Revere rode to warn American patriots northwest of Boston that the British intended to raid Lexington and Concord. The British had two objectives: to capture Samuel Adams and John Hancock, Massachusetts delegates to the Second Continental Congress, who were staying at Lexington; and to seize the store of patriot arms at Concord. As a result of Revere's warnings the Lexington minutemen were ready for the British.

Revere was one of two messengers sent by Boston patriots to spread the alarm. The other was William Dawes. The British embarked by boat from Boston across the Charles River to Charlestown. Dawes immediately left Boston on horseback and threaded through the British patrols guarding the narrow Boston Neck and Cambridge. Revere had two lanterns hung in the North Church tower. This was a prearranged signal to Charlestown patriots that the British were proceeding by boat. Then he stepped into a skiff and was rowed across the river. His oarsmen pulled well to seaward to avoid the British frigate *Somerset* anchored in the river mouth.

In Charlestown, patriots warned Revere that British patrols were on the roads. He nodded and set off on the ride made famous by Longfellow's poem, 'Paul Revere's Ride'. Near Cambridge, two British horsemen loomed in his path. Revere wheeled his horse and got away. In Medford he aroused the minutemen, and one by one the residents of almost every house.

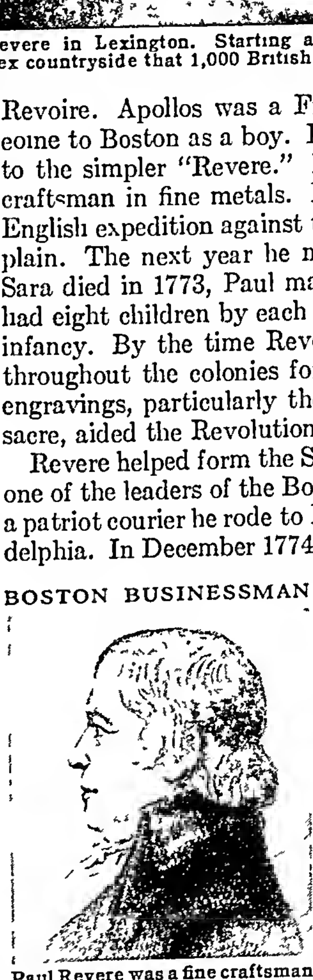
He galloped into Lexington near midnight; Dawes came a half hour later. Both then rode on to arouse Concord. On the way they were joined by Dr. Samuel Prescott. A little farther on a British patrol halted them. Dawes and Prescott escaped, and Prescott reached Concord. The British held Revere for a time, then took his horse and released him. He walked and ran across the fields to Lexington. There he heard the exchange of British and patriot shots.

Craftsman and Industrialist

Paul Revere was born Jan. 1, 1735, in Boston. He was the third child of a silversmith, Apollos De Revoire. Apollos was a French Huguenot who had come to Boston as a boy. Later he changed his name to the simpler "Revere." Paul became a competent craftsman in fine metals. In 1756 he enlisted in the English expedition against the French at Lake Champlain. The next year he married Sara Orne. When Sara died in 1773, Paul married Rachel Walker. He had eight children by each wife, five of whom died in infancy. By the time Revere was 35 he was known throughout the colonies for his fine metalwork. His engravings, particularly the one of the Boston Massacre, aided the Revolutionary cause.

Revere helped form the Sons of Liberty, and he was one of the leaders of the Boston Tea Party (1773). As a patriot courier he rode to New York City and Philadelphia. In December 1774 he rode to Durham, N.H., to advise the seizure of arms and powder at nearby Fort William and Mary, which the British were about to reinforce. The patriots used some of these arms in the battle of Bunker Hill. He engraved the plates for printing Massachusetts' first currency and set up a powder mill. He also served in the local militia.

BOSTON BUSINESSMAN



Paul Revere was a fine craftsman and owned a prosperous business.

After the Revolution, Revere carried on in business. In 1792 he opened a foundry to cast cannons and bells. He found a way to alloy copper and make brass. The famous ship *Constitution* ("Old Ironsides") was fitted with copper and brasswork made in his mill. When he was 65 he learned how to roll sheet copper. He was the first man in America to do this. His copper sheets were used to resheath the *Constitution's* bottom and to make boilers for Robert Fulton's steamboats. Paul Revere died May 10, 1818. (*See also* Boston; Revolution, American.)

The WAR *That* WON AMERICA'S FREEDOM

The Continental Congress is ready to adopt the Declaration of Independence. Thomas Jefferson presents the document to John Hancock, president of the Congress. In the committee that drafted it are, right to left, Benjamin Franklin, Jefferson, Robert Livingston, Roger Sherman, and John Adams. John Trumbull painted the original of this picture.

REVOLUTION, AMERICAN. The 13 American colonies revolted against their British rulers in 1775 and won their independence in 1781. The revolt began on April 19, 1775, when the Minutemen of Lexington, Mass., were fired upon by British regulars, and ended with the surrender of the British at Yorktown on Oct. 19, 1781. A formal peace was signed in 1783.

In overcoming the hardships of a wild, new land, the American settlers had gained strength and a belligerent belief in the rights and liberties of the individual man. So when England imposed limits on trade and industry, demanded unjust taxes, and sent British troops to compel obedience, the Americans revolted. At first they fought only for their rights and to force a just rule, but after a year of war they fought for complete independence.

The Development of Americans

The American settlers had early become used to taking a share in government. Every colony elected an assembly. Only 12 years after Jamestown was settled, the Virginians instituted their House of Burgesses. In 1620 the Pilgrims, before building their first log cabin, drew up the Mayflower Compact, a set of rules for governing their colony. (*See also* American Colonies; 'Mayflower'.)

Many settlers came to America to be free to worship as they pleased. Two of the colonies—Rhode Island and Maryland—offered almost complete religious freedom, and the other colonies gradually learned to tolerate various denominations. The settlers believed firmly in the benefits of education. Harvard College was founded in 1636, only 16 years after the Pilgrims landed, and in 1647 Massachusetts required its towns to provide primary education. The protests against British injustice printed in papers, pamphlets, and books could be read by most Americans.

Land was cheap or free. In the border wilds a man needed only to build a cabin and clear a planting space, and he was a landowner. Even a bond servant could look forward to owning a farm, once his period of service was over. Timber was plentiful, and some port towns had shipyards. American ships visited and traded American goods in foreign ports. Small industries milled grain, wove textiles, and made leather and metal articles. The Americans were inventive, hard-working, and prosperous.

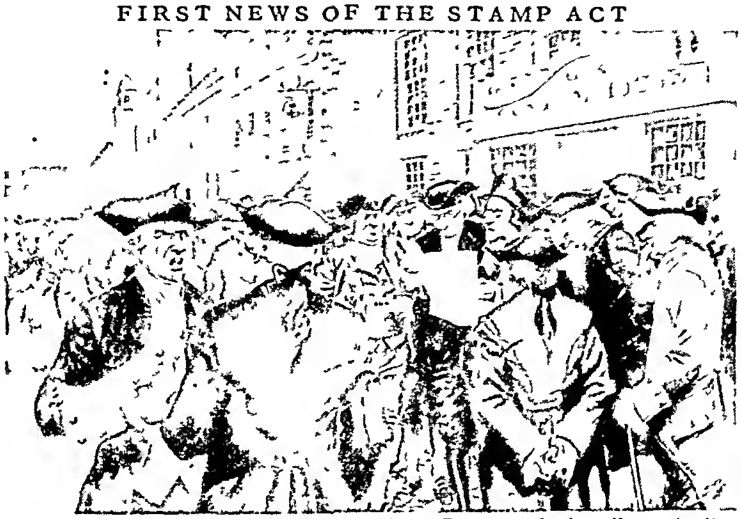
The 13 colonies shared many grievances against the mother country. But each colony was fiercely jealous of the others. Farsighted leaders in England and America tried to bring the colonists to united action on common problems but they failed. One of the efforts was the Albany Congress, called to meet in Albany, N. Y., in 1754, at the beginning of the French and Indian War. In spite of the danger to all the colonies, only seven sent representatives to discuss plans for unified action in relation to the war and

the government of the colonies. Franklin drafted the proposals, but they were never made effective.

The Result of the French Wars

The treaty of 1763 ending this war made England master of Canada and the land between the Appalachian Mountains and the Mississippi River. The whole cost of governing this vast region was suddenly shifted from France to Britain. Yet the British people already staggered under an immense national debt, and their taxes were higher than ever before. In the view of British ministers, England had made great sacrifices in order to expel the French from Canada. The chief motive had been national advantage; but as one of the results the 13 colonies might now live in peace. The British prime minister in 1763—George Grenville—did not understand the views of the colonists or concede that they had any real political rights. He thought now to place them in an imperial strait-jacket that they might become most profitable to England at the least expense.

FIRST NEWS OF THE STAMP ACT



Indignation blazes on every face as these Boston colonists listen to the reading of the hated Stamp Act just arrived from England. To one side is the royal custom-house, adorned with the crown and the initials of *Georgius Rex* ("George, King" in Latin). From Harold Rugg's 'A History of American Government and Culture' (Ginn).

Settlers were now pouring into the Ohio Valley, and land speculators were busy with schemes for opening the country won at so great a sacrifice from the French. Such activity excited the worst fears of the Indians. Land, fur-bearing animals, the redman's very existence—all would be engulfed by the remorseless advance of the whites. Fur traders were debauching the Indians with rum and cheating them of their furs. Up and down the western rivers traveled French agents who incited the tribes against the English, promising that a huge French army was on the way to recover the lost lands for the redman and France. Now there emerged a great chieftain, Pontiac, who united the tribes in 1763, and led them in a series of destructive raids on the advancing frontier.

Restriction of Westward Settlement

With the purpose of quieting the Indians, England issued the Proclamation of 1763, which forbade settlers to buy lands beyond a line running through the sources of the rivers flowing into the Atlantic. England, it seemed, meant to favor the Indians and the fur traders at the expense of the pioneer, the land speculator, and the colony whose charter gave it a claim to a section of the interior westward to the Mississippi River.

But the settlements east of the "Proclamation Line" were not to be neglected. For their defense England decided to station a large army on the frontier. Should the colonies contribute toward the expense of this protection? Yes, said England—and by paying taxes imposed by Parliament.

Trade offered one source of revenue. The old Molasses Act, having yielded but little income, was modified in 1764. The colonists now had to pay import duties on foreign molasses, sugar, wine, and other commodities. More important, measures were adopted to prevent smuggling. Revenue officers sought writs of assistance allowing them to search homes for smuggled goods, and James Otis gained fame in his flaming attack upon their use (*see* Otis, James). Since this new Sugar Act would not afford a large revenue, it was supplemented in 1765 by the Stamp Act (*see* Stamp Act). This levied a direct tax on all newspapers printed in the colonies, and on most commercial and legal documents used in business. It was realized that these two revenue acts would provide less than half the money needed for the army. Another measure—the Quartering Act—required each colony to bear part of the expenses incurred by the British troops when stationed or moving within its borders. The Currency Act of 1764 increased the load of taxes to be carried by the colonists, for it directed them to pay, within a fairly short time, the whole domestic debt which they had created for carrying on the French and Indian War.

The Outcry Against the Stamp Act

Opposition to the Stamp Act spread through the colonial assemblies, especially that of Virginia (*see* Henry, Patrick). It came to a head in the Stamp Act Congress of 1765, which asserted that the colonists, as English subjects, could not be taxed without their consent. Alarmed by the refusal of the colonial towns to buy additional goods while the act remained in force, British merchants petitioned Parliament for its repeal. Meanwhile, Grenville was succeeded by Lord Rockingham, a minister more friendly toward the colonists. In repealing the Stamp Act in 1766, Parliament at the same time declared that it had full power to tax the colonies whenever and however it thought best.

The Issue of Taxation

During the Stamp Act controversy a Maryland lawyer, Daniel Dulany, wrote that although Parliament might lay external taxes on the trade of the colonies, it

could not rightfully impose internal taxes to be collected directly from the people. This distinction became immensely popular at the time. When Charles Townshend was Chancellor of the British Exchequer he framed his famous revenue act of 1767 in line with the colonial view. Duties were placed on lead, paint, glass, paper, and tea, when imported into the colonies. The money collected was to be used to support British officials in the American service. Colonial opposition to these taxes was not foreseen.

But the colonists objected strenuously. Their leading spokesman this time was John Dickinson of Pennsylvania. In his widely read 'Letters of a Farmer in Pennsylvania', he made a new distinction—between taxes levied to regulate trade and those intended to raise a revenue. If the purpose was to promote imperial commerce, the tax was justifiable. But if England could levy taxes simply to obtain a revenue, the colonial rights of self-government would soon be at an end. Only through their power to withhold the salaries of British governors had the colonial assemblies been able to keep them in hand. If England should now pay such salaries from Parliamentary taxes, the governor—upon becoming independent of the assembly—would soon be able to squeeze it to the size of a pigmy and dwarf most of its activities.

Tea and the "Tea Party"

In 1770, a new prime minister, Lord North, believing it unwise for England to hamper the sale of her own wares in outside markets, secured the repeal of most of the Townshend duties. At the request of King George III the duty on tea was left, in order to assert the right of England to tax the colonies. The American merchants accepted this compromise, and the agitation in the colonies soon died down. The remaining duty was evaded by smuggling: about nine-tenths of the tea imported after 1770 did not pay the odious tax.

Then, in 1773, Parliament passed another act that set all the elements of discord in motion. This allowed the British East India Company to ship tea to the colonies without paying any of the import duties collected in England. The Company, near the brink of bankruptcy, had on hand an immense quantity of unsold tea, which it could now sell more cheaply in the colonies than tea imported by local merchants, who had to pay the high duties in force in England. The Company was quite willing to pay the Townshend tax of threepence a pound when its tea was landed in America.

In the colonies this cheap tea was greeted as a bribe offered to the people for their consent to a British tax. The merchants were everywhere alarmed. If the East India Company might receive a monopoly for the sale of one article, it might receive other privileges, and the local merchants would then be deprived of most of the colonial trade. In New York and Philadelphia, the Company's ships were not allowed to land, while at the Boston Tea Party a group of citizens, disguised as Indians, tossed £15,000 worth of the offensive tea into the harbor. This brought about the greatest pre-revolutionary crisis, for it was the first act of resistance which had ended in the destruction of a large amount of private property. Since the East India Company was carrying out a British law, Lord North and George III felt that if the colonial opposition went unchallenged, England's authority in America was a thing of the past.

BOSTON'S £15,000 TEA PARTY

"King George will never collect a tax on this tea," say these Boston colonists, disguised as Indians, as they haul the cargo from the hold of the East India Company tea ship and heave it overboard.

The Five "Intolerable Acts"

Parliament replied to the Boston Tea Party with the five "punitive," "coercive," or "intolerable" acts of 1774. One of these closed the port of Boston until the East India Company was paid for the lost tea. Since commerce was the life-blood of Boston, this act inflicted hardships on all the townspeople, the innocent and the guilty alike. A second act modified the Massachusetts charter of 1691, taking away many of the most highly prized rights of self-government which that province had long enjoyed.

The third measure provided that British officials accused of committing crimes in a colony might be taken to England for trial, and the fourth allowed the governor of Massachusetts to quarter soldiers at Boston in taverns and unoccupied buildings. The last act—not intended to punish the colonies—extended the boundaries of the province of Quebec to the Ohio River and gave the Roman Catholics there both religious liberty and the double protection of French and English law.

Had the colonists accepted these acts they would have yielded nearly all their claims to the right of governing themselves. Neither they nor England could now back down without a complete surrender on the part of one or the other.

Why did the final break occur? Ever since the beginnings of settlement, England and America had been growing apart. In 1774, England was still an aristocracy, ruled by men born and bred to a high station in life. Their society was largely one of culture and refinement. The common people, deprived of abundant opportunity at home, accepted a position of dependence. Hard work, deference to superiors, a future without promise, and submission to rulers they did not select—such was their lot in life.

Old England and the "New Englands"

But in America things had taken a different turn. The tone of society was essentially democratic. There were no lords or hereditary offices. Manners were yet crude and society wore a garb of rustic simplicity. The wilderness had attracted men of independent spirit, and the stern conditions of the frontier had bred self-reliance and self-respect. The Americans did not like to look up to superiors, nor were their leaders set apart by privileges of birth and inherited wealth. The opportunities of the New World made men enterprising, energetic, and aggressive. Restraints were few, custom counted for little, and rank for less. Between these two societies there could not be much in common. Convention, decorum, and formality guided the aristocracy of England. Her leaders looked down upon the crude manners of the Americans—their uncouth dress and speech, their boisterous ways, their lack of formal education, and their aspirations for independence and self-rule. Most ancestors of the Americans had belonged to that humble class which was still without political rights or influence in England. What magic of the American woods could transform these lowly folk into peers of the chosen few who lived on the fat of England's fertile soil?

Breaking of Charter Contracts

Equally wide was the gulf that separated the colonists and England in their political thinking. By 1750 British statesmen believed that Parliament had complete authority over the colonies. It could tax them, make laws for them, and even abolish their elected assemblies.

All this the patriot leaders in America denied. Parliament was not a free agent, they said. It was bound to respect certain natural rights of man; any of its acts which tried to take these away from British subjects was automatically void. The king, not Parliament, was the link that really bound the colonies to England. They had been planted under his auspices, and the colonial governments rested on charters that he alone had issued. These charters were regarded as contracts between the king and the first settlers, giving them and their descendants the rights of life, liberty, and property. Should England try to take away these rights, the original contract would be broken and the Americans released from their duty of allegiance to the king.

Taxation Without Representation

Foremost among these rights was the one expressed by the saying—"a subject's property cannot be taken from him without his consent." The colonists denied that they were represented in Parliament; therefore they did not give their assent to taxes it imposed. The English leaders, on the other hand, held that all members of Parliament looked after the best interests of the whole empire, and that the colonists were as fully represented as the great mass of English people, who did not have the right to vote at home. Since they believed themselves unrepresented in Parliament, the Americans agreed that only a locally-elected assembly could tax them. In fact, the revolutionary leaders eventually placed the assemblies on a par with Parliament. It should have no more power over them than they had over it. This view meant that the colonies were virtually independent states, held to England by ties of sentiment, but not actually subordinate to her. By 1750 the king could do scarcely anything without the consent of Parliament. Thus the American leaders, by asserting that the colonies were subject solely to the king, recognized only a feeble authority too weak to control them in an effective way.

Misgovernment and Exploitation

The defects of British rule also contributed to the final break. For a long time England had let the colonies drift along with little restraint. There was no central colonial office which was supposed to supervise them; executive authority in England was divided among several ministers and commissions that did not act quickly or in unison. The Board of Trade, which knew more about the colonies than any other body, did not have the power either to decide things or to enforce decrees. English politics were honeycombed with corruption, and agents sent to America were often bribe-taking politicians too incompetent for good positions at home. Distance also counted against England. "Seas roll, months pass between the order and the execution," wrote Edmund Burke. Just before the Revolution, England was governed by rapidly changing party factions that did not hold to a consistent course.

Ascending the throne in 1760, George III endeavored to check the growing power of Parliament and to become himself the ruling force in English affairs. His arbitrary acts raised up powerful opponents in England, who regarded the colonists as fellow sufferers in a far-flung struggle between liberty and tyranny. Divided counsels at home, corruption and inefficiency in government, authority divided at the top, sudden changes of policy, measures boldly announced but feebly enforced—all these brought England's claims over the colonies into disrepute. When the Americans had resisted, they had usually gained their point. The liberty they had long enjoyed only whetted their appetite for more.

The Colonies as a Source of English Profits

England always treated the colonies as sources of profit to herself, regarding them as dependencies and endeavoring to utilize their resources for her own gain. In the New England woods she tried to prevent the local lumbermen from sawing planks out of trees capable of furnishing masts for the Royal Navy. After 1763 she proposed to control the granting of land in

the West with an eye to her own advantage. Since land was the principal source of wealth among the colonists, they could not prosper to the utmost until its benefits were freely accessible to all the people.

England also controlled the commerce of the empire in order to increase her own wealth. In accordance with England's "mercantile theory," her policies directed that the colonies should produce what she did not and exchange it in her own ports for British goods. As far as possible, the profits of American trade should go to British merchants, and the ready money of the colonies should come to Britain in payment of colonial debts. The assemblies should not do anything to restrict the sale of British merchandise in America, nor should the colonists produce the kind of wares which Britain could supply. These various principles were given force by a series of Acts of Trade that greatly limited the economic opportunities of the colonies and left them little more than farming.

Meanwhile the colonists became increasingly dissatisfied with this condition. Their agricultural produce sold abroad did not bring enough revenue to buy all the manufactured goods they needed. After they became indebted to British merchants, they often felt that they were exploited by their creditors. Denied the right to develop local manufactures, they produced an ever-growing surplus of a few agricultural staples which, flooding the available markets, lowered the final sale price abroad.

HIDING FROM THE PATRIOTS

This quaint old engraving shows a gathering of Tories in a dim-lit cellar, amid casks and vegetable bins. They had to meet in secret, for if the state government found they had remained loyal to England, they might be banished from their homes and their property seized. Many fled to Canada.

The remedy for this condition was to cut down the agricultural surplus by developing local manufactures and by engaging in free commerce with all the world. A vast share of America's wealth went to British manufacturers, shipowners, and merchants. Should Americans perform the services formerly supplied by Britain, their wealth would increase, their debts would diminish, and economically they would stand on their own feet.

While the colonies were sparsely peopled and undeveloped, the settlers realized that the benefits they derived from England outnumbered the losses inflicted by British restrictions. Now, however, in 1775, the American people were approaching the stature of manhood. Their population exceeded two and a half million, and their growing wealth was able to support new enterprises of which England disapproved. The time had come when it seemed that the Americans could do for themselves what England had done before, and that the increase of wealth which freedom promised would overbalance the cost of defending their frontiers, of maintaining a navy, and of securing commercial privileges for their products abroad in free trade with other countries besides England.

The Organization for Revolution

That they might act together in resisting the measures of Britain, the colonists built up an effective revolutionary organization. This may be likened to a pyramid. The bottom stones consisted of committees of correspondence first erected in the New England towns through the influence of Samuel Adams and at the suggestion of Boston. Elsewhere such committees were generally established in the counties. They enabled the people of each locality to act together, and to communicate with fellow colonists in remote places. When the break with England came, these and similar committees took charge of the work of local government (*see* Adams, Samuel; Lee, Richard Henry).

The next layer of the pyramid consisted of provincial congresses. These in some cases were the former assemblies meeting in defiance of the English governors. Others were unauthorized bodies composed of delegates selected by the committees in the towns or counties. When England's authority was rejected, these congresses were ready to make laws, and to provide soldiers and money for carrying on the war.

At the apex of the pyramid stood the Continental Congress. The delegates who attended its first meeting at Philadelphia in 1774 were nearly all members of local committees of correspondence, and many of them had been selected by the provincial congresses. They elected Peyton Randolph, a Virginia lawyer, as president. The Congress denounced parliamentary taxation and the "five intolerable acts." It signed a "Continental Association" intended to destroy all trade with England if the British did not yield. The Congress prepared to enforce this agreement on all communities by means of the local committees.

The only authority which the Congress had came from the people themselves, and its acts were not regarded by England as law. When it attempted to force everybody to follow a certain course of action, it assumed the power of a *de facto* government. The colonial leaders had now divided into two camps—the Patriots, willing to accept the Congress as their guide,

and the Loyalists, who were willing to abide by Parliament's decree and counseled submission.

Conciliation or Force

Meanwhile the air was full of plans for conciliation. Lord North suggested that England should not tax the colonies if they would provide a permanent revenue for the support of British officials stationed there. Let the colonists return to their old ways, said Edmund Burke; let them vote their own taxes and govern themselves. William Pitt (now Lord Chatham) would repeal the "intolerable acts" and promise that taxes should not be levied by Parliament except with the consent of the American assemblies. At the first Continental Congress, Joseph Galloway of Pennsylvania proposed to erect an American legislature, subordinate to Parliament, which would have the right to veto all British laws relating to the general interests of the colonies. Some leaders would admit American representatives into Parliament, and a few Englishmen were ready to give the colonies their independence. But all these plans failed. The conciliators were unable to induce either side to make any real concessions to the other, and the issue had to be decided by force.

Fights in and about Boston

British troops were sent to Boston, the center of resistance, as early as 1768. On March 5, 1770, the friction between them and the townspeople flamed into violence at the Boston Massacre, when the soldiers fired into a mob killing five men and wounding several others.

The enforcement of the "intolerable acts" by a military governor and troops set the people seething with the spirit of revolt. On the memorable night of April 18, 1775, Paul Revere and William Dawes rode through the country spreading the hurried news that British "redcoats" were coming to Lexington to seize Samuel Adams and John Hancock, and to Concord to capture the stores of war which the patriots had gathered there. Embattled farmers assembled at Lexington on the road from Boston, and there occurred the fighting which proclaimed the coming of war. (*See* Hancock, John; Lexington and Concord, Battle of; Revere.)

War: Handicaps of the Americans

Five and a half years elapsed before the land again enjoyed peace. Why did the war last so long? At the start the Americans did not have a unified army. Their first forces consisted of colonial militia headed by local leaders not accustomed to taking orders from a superior commander. Nor did the ordinary soldiers like to obey their officers. There was no central system of housing, paying, or feeding the troops, and supplies of gunpowder and clothing were inadequate. When a common army was formed, short-term enlistments required that it be frequently built anew, and it probably never contained more than one-tenth of the Americans who could have given military service.

All the time the states were rent by party strife. Perhaps a third of the people remained faithful to the king. They served at times in his army, fitted out privateers to prey on American commerce, and plundered the property of patriot farmers. In retaliation the states confiscated the wealth of these Loyalists or Tories, drove thousands of them from their homes, and declared any person who joined the British army a traitor deserving death. Unscrupulous profiteers sold supplies to the king's forces when the American army was in dire need. This lack of unity at home and the need of conquering two foes at once weakened the efforts of the patriots and postponed the final hour of victory.

Mistakes and Jealousies

The Revolution was a new and strange undertaking, requiring 13 states jealous of their local rights to act in unison. At times the South felt neglected by Congress, and often the states held back in giving aid, each fearing that it would carry more than its share of the burden. In those days of stress, when things went wrong, all the people could not agree on a single remedy or follow leaders without criticizing them. Many mistakes had to be made before the right

"IF THIS BE TREASON, MAKE THE MOST OF IT!"

Cries of "Treason!" echoed in the Virginia House of Burgesses when Patrick Henry fearlessly opposed King George's tax laws. This painting by P. F. Rothermel has caught the tenseness of the scene.

methods and the best leaders were discovered. There were personal jealousies, also. Benedict Arnold, placed in charge of West Point, which had been strongly fortified by Kosciusko, plotted to deliver this strategic point to the British, partly because he thought he did not get enough recognition for his services to the patriot cause. (*See* André; Arnold, Benedict; Kosciusko; Military Academy, United States.)

The incompetence of Gen. Charles Lee accounted for two costly American disasters. When Washington was enduring every conceivable hardship at Valley Forge in 1777–78, an intrigue in Congress known as the "Conway Cabal" aimed to put General Gates in his place as commander-in-chief.

THE FIRST FIGHTING OF THE AMERICAN REVOLUTION

This little band of Minutemen at Lexington, Mass., April 19, 1775, shed the first blood in the long war for American freedom. But they were unable to hold their ground against the large force of Redcoats glimpsed through the smoke of musket fire.

All in all, it was a stupendous task that faced the patriots. They had to improvise an army and a new government at the same time, to meet unusual situations arising every day, to find trusted leaders, and to get 13 proud states to work for the common cause. And all this had to be done with little preparation, without the aid of settled rules, and with the ever-present menace of defeat and reprisals for rebellion and treason casting a black shadow over the land.

The Problem of Finances

Moreover, the Continental Congress never had the right to levy taxes. When it asked the states for money, those not immediately in danger frequently failed to respond. Little aid at first could be obtained abroad; many of the wealthiest men in America remained Loyalists; and the patriots could not seize people's property for war purposes without raising a storm of opposition. All these conditions forced Congress to issue an immense volume of paper money or bills of credit. These bills were promises to pay the holders of them a certain sum of money in the future. Congress used them to buy supplies and to compensate the soldiers. Each state was supposed to provide money to enable Congress to give silver to the owners of the bills. But this was not done, and no cash fund was created to keep up their value.

As the paper currency passed from hand to hand, it gradually became worth less and less in silver, so that the loss was spread over a long time and borne by all the people. Thus if a person received a paper dollar when it would buy 90 cents in silver or goods, and if its real value had fallen to 85 cents when he used it again, he lost 5 cents in the transaction. When this Continental currency became worthless, Congress called upon the states for quotas of food for the army, but this proved to be a very wasteful method. A large sum of money was borrowed from private citizens who received interest-bearing securities of the United States in return.

During the early years of the war, when Congress did not have a navy, England easily controlled the sea. Her powerful fleet enabled her to blockade much of the coast, and to strike wherever she chose, capturing American ports almost at will. Her wealth, industrial resources, and military experience provided her with well-equipped troops—some of them Hessians, hired in Germany—under the command of seasoned officers. So great were the odds against the colonies and so powerful was England at the start that other European states hesitated to help Congress lest they raise against themselves a dreaded foe.

Advantages of the Americans

But in the long run stronger influences favored the Americans. They knew the lay of the land where the fighting had to be done better than the British did, and were used to the rough living conditions which war brought in its train. The typical settler felt quite at home with a rifle in hand. The damage done by the redcoats incensed the people and aroused their fighting spirit. Britain's soldiers had no real interest in the war, while the Americans were defending their firesides and their settled way of life. Acting on the defensive, they could afford to wait till England moved and then assemble their forces where danger threatened most.

If the colonists were really to be subdued, the whole countryside had to be conquered. Their communities were largely self-sufficient units that could not be crushed by the capture of a single city or an important road. This meant that England had to wage a series of campaigns on land. The

difficulties of moving an army over miry roads were terrific. Nor did England have enough troops to occupy all regions at once. When it concentrated on the middle states it had to neglect New England and the South. It could not keep soldiers in every village, and when they were withdrawn the people were ready once more to take up arms. At a time when an army could march only a few miles a day, it was a stupendous task to subdue isolated settlements stretching from Maine to Georgia and reaching in places 300 miles beyond the coast. All the greater was the difficulty when the invaders had to bring troops and supplies across the ocean.

Foreign Aid

However, without help from Europe the Americans might not have won the day. The hope of such aid was one important reason why Congress adopted the Declaration of Independence in 1776, for European states would not interfere so long as the colonies still recognized the English king (*see* Declaration of Independence). Agents now sent to France were able secretly to procure clothing and muskets. Individual Frenchmen—headed by the Marquis de Lafayette—served as volunteers in the American army (*see* Lafayette). The great victory of Saratoga in 1777, made possible by gunpowder received from France, seemed to assure the final triumph of the American cause (*see* Saratoga Springs).

France now recognized the independence of the United States and formed an open alliance with Congress. France's foreign minister, the clever but unscrupulous Vergennes, persuaded King Louis XVI that England was about to make peace with the colonies and join with them to seize the French West Indies. The new alliance made it possible for Congress to borrow an immense sum of money from France. French troops were sent to take part in the war and they fought to the end at Yorktown. The French navy blockaded Cornwallis' forces in Yorktown and hastened his surrender. France also induced Spain to make war on England in 1779.

Aid likewise came from other sources. Baron von Steuben, a German trained in the army of Frederick the Great, taught American officers the art of war, and helped to make the troops better fighters (*see* Steuben). An outlet for American produce was found at a Dutch island in the West Indies. There likewise military stores were obtained. England's power on the sea forced Russia, Prussia, Denmark, Sweden, Holland, and the German Empire to enter into a league of armed neutrality in 1780. These states asserted that goods carried in a neutral ship should not be seized in time of war. The Dutch secured so much trade that England declared war on them in 1780 in order to take away their rights as neutrals. Congress was then able to borrow additional funds from Holland, and England was confronted by the combined fleets of three continental foes.

BURNING OF THE 'PEGGY STEWART'

Annapolis patriots, enraged by the tea tax, forced the owner of the *Peggy Stewart* to fire his ship and its cargo of tea. Here the patriot leader and the shipowner confer as the vessel burns.

Naval Activities

The United States was not wholly powerless on the sea. Trading vessels were quickly prepared for fighting service, while Congress appropriated funds for the construction of a navy.

Meanwhile special letters of authority were given to merchantmen allowing them, as privateers, to seize British vessels. These merchantmen took so many of the enemy's ships that ocean insurance rates increased tremendously, and English merchants began to see the advantage of an early peace.

American warships under the command of Esek Hopkins, John Paul Jones, and John Barry proved themselves equal to English frigates, and in 1779 even the remote British coast felt the sting of direct contact with the American war (*see* Jones; Navy, section "The History of Navies and Sea Fighting").

The American Leaders

The needs of the time brought forward an unusual group of leaders. George Washington, as commander in chief of the army, kept the American cause on its feet, inspiring hope by his courage, patience, and firmness during the darkest hours of defeat (*see* Washington, George). To Benjamin Franklin belongs much of the credit for securing aid from France (*see* Franklin). As an agent of Congress, he became the idol of Paris, using every art of diplomacy to win the good will of all classes in French society. Robert Morris took charge of raising money for the war (*see* Morris, Robert). Others, like John Adams and Thomas Jefferson, struggled against discord in Congress and rallied the people against despair (*see* Adams, John; Jefferson). The Americans as a whole were a tough, sturdy race, able to endure privation and hardship. Rarely has a country with so small a population as the

13 states produced so many first-class leaders in a single generation as did the American Colonies.

The Whigs in England

One other thing favored the Americans: England was not united at home. Setting out to be a real ruler, George III became the leader of the Tory party, and attempted to make the king superior to Parliament (*see* George III). His opponents, the Whigs, believed that he was ready to destroy the liberties of the English people. His arbitrary course called forth a reform movement: more people should vote, and the king should not stifle criticism of his acts as he had done. One group of Whigs, headed by Lord Rockingham, believing that the colonies could not be subdued, wanted to give them their freedom. Others favored compromise. Even Lord North disliked the war, but when he tried to resign, George III threatened to leave the throne. Lord North stayed, acting against his better judgment in order to please the headstrong king. All the while the Tories stiffened the resistance of the Americans by treating them as hateful rebels. Moreover, opinion was changing; Adam Smith, in his 'Wealth of Nations' (1776) argued that the trade of free states in America would be as profitable to England as the trade of colonies. Alarmed by defeats in 1781 and uprisings in Ireland and India, Parliament in 1782 demanded the king end the war.

The Story of the War on Land

When the British fell back from Concord to Boston in April 1775, the farmer militiamen of New England immediately besieged the city. The Second Continental Congress, meeting at Philadelphia in May 1775, now took charge of the war and appointed Washington commander-in-chief. Before he arrived at Boston, the New Englanders had made a valiant attempt to hold Bunker Hill, preparatory to bombarding the British troops and fleet in the city. Forced to retire by lack of powder, the Americans had given a demonstration of bravery and skill that left England little cause for rejoicing (*see* Bunker Hill, Battle of). The New England militiamen, soon reinforced by Continental troops, held the city beleaguered until the British commander, Lord Howe, elected to move his army to Nova Scotia in March of 1776. New England thereafter escaped the ravages of war on land.

DARK DAYS AT VALLEY FORGE

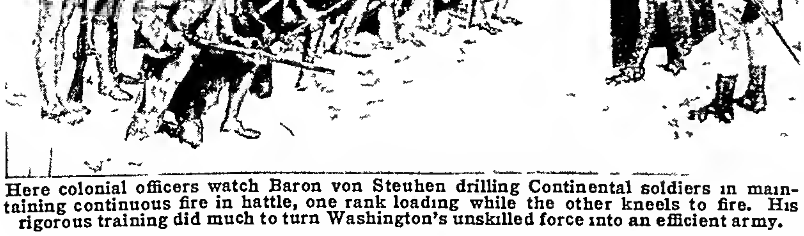
This old engraving, showing Washington praying in the snow at the Valley Forge encampment, aptly symbolizes his anxiety for his ragged army during that bitter winter when American fortunes were at a low ebb.

American Offensives in the North

While Washington kept Howe bottled up in Boston, the Americans assumed the offensive to the west and north. In May 1775, Ethan Allen, leading his Green Mountain Boys and accompanied by Gen. Benedict Arnold, captured Fort Ticonderoga, on the Lake Champlain waterway (*see* Allen). Generals P. J. Schuyler and Richard Montgomery, with 1,200 men, joined Allen at Fort Ticonderoga. On August 30 they marched northward toward Montreal. In September Montgomery laid siege to the Montreal defenses of Fort Chambly and Fort St. Johns. He captured the first in October. Fort St. Johns, with 400 men, fell into American hands in early November. Montreal was entered without further fighting on November 13.

About the same time, Gen. Benedict Arnold, with 1,000 volunteers, marched northwestward through the Maine wilderness toward Quebec. The hardships of the march so reduced his force that only 550 men reached the Quebec defenses. Montgomery came down the St. Lawrence with 450 men to aid the attack on Quebec. An attempt to storm the city on December 31 failed. Montgomery was killed at the start of the battle, and the Americans lost

TRAINING THE PATRIOT ARMY



Here colonial officers watch Baron von Steuben drilling Continental soldiers in maintaining continuous fire in battle, one rank loading while the other kneels to fire. His rigorous training did much to turn Washington's unskilled force into an efficient army.

almost one-third of their men. The Americans withdrew for the winter. By spring of 1776 reinforcements increased the American strength before Quebec to about 1,000 men. This force besieged Quebec through parts of April and May. But the Americans withdrew when they learned that Burgoyne, with 10,000 soldiers, was sailing up the St. Lawrence.

The British retook Montreal and sent a force south to Lake Champlain. Arnold built a small fleet of boats to stop the British advance. Although defeated on October 11, the Americans inflicted considerable damage at the battle of Valcour Island. Arnold then retreated to Crown Point and Fort Ticonderoga, where his small force blocked the British effort to drive to a meeting with Howe in New York. The British had failed in their first attempt to isolate the New England area from the other states (*see* Arnold, Benedict).

New York and the Hudson

In July and August 1776, Howe's army was built up to a force of 32,000 men on Staten Island, in the New York harbor. In New York City and on Long Island, Washington had about 20,000 poorly armed men to oppose the British.

Howe sent 20,000 men across the narrow water from Staten Island to Long Island. On August 27 this force routed the Americans on Brooklyn Heights. The victorious British followed the Americans across the East River to Manhattan. For a time Washington held Harlem Heights but then retreated to White Plains. There, on October 28, Howe's superior forces drove back Washington's army.

Two American forts, Washington on the east bank and Lee on the Jersey shore, guarded against a British advance up the Hudson. But the forts fell quickly under British attack, and the British now held the entire New York City area. The New York harbor was Howe's to use as the chief British invasion port.

In the final weeks of 1776, Washington retreated across New Jersey, his army a ragged remnant numbering only 3,000 men. But in defeat the army had learned the business of soldiering. On the Delaware Washington collected all available boats and crossed to Pennsylvania.

American Victories at Trenton and Princeton

While the Hessians celebrated Christmas night in Trenton, Washington ferried his tired men across the Delaware. The next morning he attacked. Colonel Rall was killed and almost 1,000 Hessians captured. Washington returned to the Pennsylvania bank.

A few days later Washington again crossed to Trenton. Here his scanty force was reinforced by 3,600 men. General Cornwallis advanced to give battle. But the British general had divided his force, and Washington quickly marched on to Princeton. On Jan. 3, 1777, he pounced upon the British left there. Washington then went into winter quarters at Morristown. Cornwallis retired to New Brunswick.

American Victory in the North

The British strategy for the 1777 campaign was for Burgoyne to march south and Howe north to a juncture on the Hudson. This would cut New England off from the rest of the states. And the British considered New England the hotbed of the Revolution.

During the winter of 1776–77, Burgoyne gathered his forces. In June a diversionary force of Indians and British soldiers, 1,600 men, under Col. Barry St. Leger sailed up the St. Lawrence to Lake Ontario. From Oswego, on the New York shore, he struck eastward toward Fort Schuyler. The British plan called for St. Leger to fight his way down the Mohawk Valley to a meeting with Burgoyne at Albany. At about the same time as the St. Leger move, Burgoyne, with the main force of more than 7,500 men, headed south and surrounded Fort Ticonderoga. The Americans in the fort broke through the British lines and took refuge at the juncture of the Mohawk and Hudson rivers.

St. Leger was defeated at Oriskany. The Americans reinforced Fort Schuyler. St. Leger gave up his part of the British plan and retired to Montreal. On August 16 a Burgoyne foraging party was routed by American irregulars at Bennington, Vt. Burgoyne, lacking supplies and reinforcements, crossed the Hudson to a more secure position. Here he lost two battles at Freeman's Farm to an American force of 17,000 under Gen. Horatio Gates. On Oct. 17, 1777, Burgoyne surrendered his remaining force of about 5,800 men at Saratoga. The second British attempt to split the states had failed. (*See* Burgoyne.)

The Americans Lose Philadelphia

In the summer of 1777 Howe, instead of marching north to meet Burgoyne's southward thrust according to the British plan, chose instead to take the American capital, Philadelphia. From New York he sailed south to Chesapeake Bay and landed in Maryland. Washington's army lay on Brandywine Creek, between him and Philadelphia.

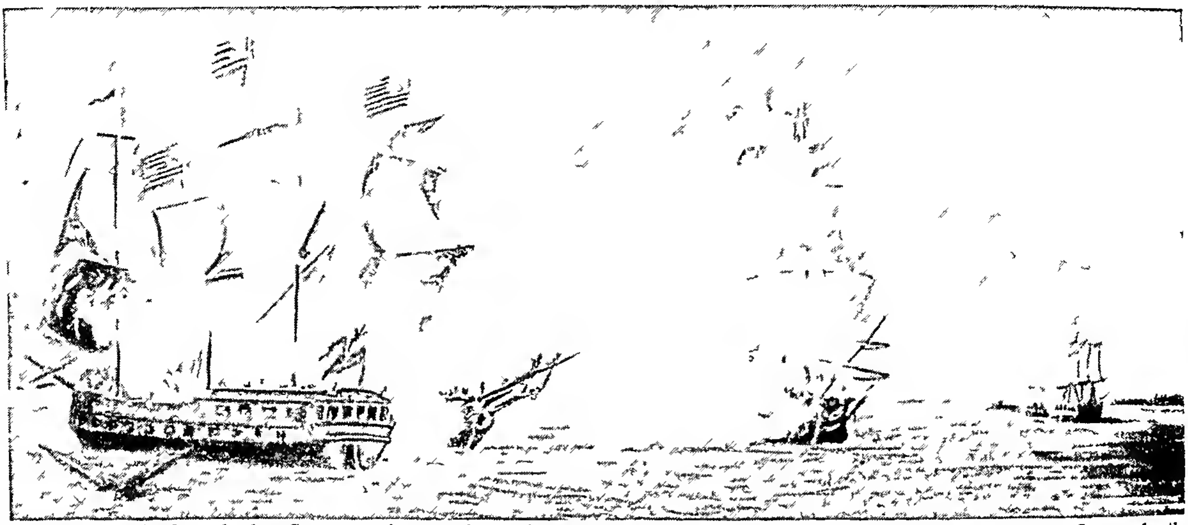
On September 11 Howe made a sharp feint at Washington's front on the Brandywine. But the main British force circled north and flanked the Americans. Only darkness saved Washington from a complete defeat. He retreated to Chester, Pa. Several days later the Americans suffered another defeat at Paoli, Pa., when a detachment under Gen. "Mad Anthony" Wayne was surprised (*see* Wayne). Several hundred Americans were killed under a British bayonet attack. The American Congress fled from Philadelphia to York, Pa., and Howe entered Philadelphia without opposition in late September.

At Germantown, on October 4, the Americans seemed to have won a victory until the British made a determined stand in the Chew house. British reinforcements came up from Philadelphia while the besieged house still held out, and Washington's little army retreated. The Americans took up winter quarters at Valley Forge.

The Bitter Winter at Valley Forge

The winter the Continental Army of 11,000 passed at Valley Forge was the darkest of the Revolution. Washington's men were without adequate food or shelter, and Congress was unable to improve their plight. Hundreds of horses and oxen died of starva-

'BONHOMME RICHARD' TAKING THE 'SERAPIS'



Here we see the British ship *Serapis* exchanging broadsides with the *Bonhomme Richard*, flying the new American flag, under the Yankee commander John Paul Jones. This famous sea battle was fought by moonlight off the northeast coast of England, Sept. 23, 1779. Although his ship was sinking, Jones fought desperately until the *Serapis* lowered the Union Jack

tion. Men yoked themselves to draw the heavy wagons of provisions to their comrades. But there was never enough food. Some 3,000 men did not have shoes, and they protected their feet by wrappings of rags. The shelters were huts or wigwams of twisted boughs. During the winter many died and 2,000 deserted. But to this dwindling, ragged army came Baron von Steuben, a German military expert under Frederick the Great. In the days of the bitter winter he trained the American soldiers and their officers in military science (*see* Valley Forge).

The French Become Allies

In Philadelphia, Clinton replaced Howe as the British commander. Early in the spring of 1778 he learned that France had allied itself with the Americans. Clinton feared that a French fleet would enter the Delaware and cut him off from New York. In mid-June he began to march his army to New York

On June 28, Gen. Charles Lee, Washington's deputy commander, withdrew after a brief contact with the marching British at Monmouth Courthouse (now Freehold, N. J.) Washington had ordered him to strike hard. The main army under Washington appeared as Lee retreated. Washington harshly censured Lee and rallied the Americans to attack. The battle continued throughout the day but did not prove decisive. Under cover of night the British withdrew.

The British settled in New York and Washington camped at White Plains France sent a fleet, some soldiers, and supplies to America. During the next two years there was little important fighting in the north and central colonies. A combined French and American attack on Newport failed. In 1779 Wayne revenged his defeat at Paoli by beating the British at Stony Point. But the theater of decisive fighting shifted to the South.

Battles in the South

The British had tried to take Charleston, S. C., in June 1776 but were driven off by Gen William Moultrie. In December 1778 a British force sailed from New York and captured Savannah, Ga. And for most of the rest of the war Georgia remained in British hands. In September and October of 1779, Gen Benjamin Lincoln besieged the British forces in Savannah. A French fleet aided in the siege. But Savannah did not fall. The Polish volunteer, Gen Casimir Pulaski, suffered a mortal wound at Savannah (*see* Pulaski).

Clinton and Cornwallis sailed south from New York and concentrated forces at Savannah. In May 1780 they attacked Charleston, which Lincoln defended with 5,000 men. Charleston fell to this second British attack.

General Gates hurriedly marched his force of more than 3,000 Americans down from North Carolina to give battle to Cornwallis' 2,300 men at Camden. The battle was fought on August 16 and Gates was beaten. He retreated to North Carolina, leaving the wounded Gen. Johann de Kalb to fall into British hands De Kalb died a few days later (*see* De Kalb).

A band of frontiersmen under Isaac Shelby and John Sevier routed a British raiding party of 1,000 regulars from a ridge of Kings Mountain, S C The British survivors fled in disorder Swift American raids led by such leaders as Andrew Pickens, Francis Marion, the "Swamp Fox," and Thomas Sumter constantly harried the British forces (*see* Sevier; Marion).

In December 1780 Gen. Nathanael Greene took command of American forces in the South (*see* Greene). He divided his force and continued the "hit-and-run" war on Cornwallis. He sent Gen. Daniel Morgan with about 950 men to Cowpens, S. C. The British Col Banastre Tarleton attacked Morgan there on Jan. 17, 1781. Morgan's force won an overwhelming victory

Cornwallis, leading the main British body, moved northward. Morgan's and Greene's forces retired before the British advance until they reached Guilford Courthouse, N. C. The American forces totaled about

WHEN THE BRITISH SURRENDERED AT YORKTOWN

The victorious American troops (on the right) and their French allies (on the left) are drawn up to receive the surrender of the British army at Yorktown, Va., in this picture by John Trumbull. Lord Cornwallis was too ill to be present, so Gen. Charles O'Hara hands his leader's sword to Gen. Benjamin Lincoln, appointed by Washington (at right rear) to accept the submission.

4,500 men; the British, 2,200. The battle was fought on March 15. The Americans won a strategic victory, and Cornwallis, with more than 500 men killed or wounded, retreated to Wilmington, N. C. Greene marched into South Carolina and engaged the British at Hobkirk's Hill and at Eutaw Springs. Cornwallis was reinforced, and in April he moved his army north.

Lafayette was at Richmond, Va., in command of about 3,000 American troops. Cornwallis' reinforcements brought his strength up to about twice that number. He planned to trap Lafayette and defeat him (*see* Lafayette). Lafayette retreated swiftly to the northwest, with Cornwallis on his heels. But the young Frenchman was too wily for the British general. Wayne, with about 1,000 men, came to strengthen Lafayette, and Cornwallis became fearful of being trapped himself. He turned eastward toward the sea to be near the British fleet.

Lafayette followed. At Williamsburg, Cornwallis turned and lashed at him, and Lafayette drew back. Cornwallis then marched on to Yorktown and threw up defenses. Lafayette moved back into Williamsburg and kept Cornwallis confined in Yorktown. Lafayette called on Washington for help. Washington was still before New York. Washington, General Rochambeau, commander of French land forces in America, and Admiral De Grasse, commander of the French fleet, eagerly seized the opportunity.

On August 30 De Grasse's fleet of 24 ships arrived off Yorktown. Cornwallis lay trapped between sea and ground enemies. An English fleet of 19 ships tried to rescue him, but De Grasse beat off the attack. In September Rochambeau and Washington joined Lafayette. Their forces now totalled 16,000. Washington took command and began to close the trap. No real battle was fought, however. On October 19 Cornwallis surrendered his 7,247 men to Washington. His surrender ended the Revolutionary War.

The Negotiations for Peace

Twice during the war England had tried to win back the Americans by offers of peace. Lord North and Parliament went so far in 1778 as to promise to yield on all points in the dispute. But it was then too late. After Congress had declared for freedom, its spokesmen took the stand that the United States was and must remain a separate nation. After the victory at Yorktown, Lord North resigned and a new ministry favorable to American independence came into power in England.

Congress named five commissioners—John Adams, John Jay, Franklin, Jefferson, and Henry Laurens—to make a treaty of peace. Jefferson did not go, and Laurens reached Europe only two days before the preliminary treaties were signed. The commissioners were instructed not to make peace without the knowledge and consent of France, for joint action in closing

the war was required by the French-American Treaty of Alliance (1778).

Disposition of the Western Lands

The great area of America lying between the Appalachian Mountain system and the Mississippi provided one of the difficult problems to be negotiated. England wanted the area and had erected posts on the Mississippi at Cahokia and Kaskaskia and on the Wabash at Vincennes. In the north they had Detroit. Spain already held the west bank of the Mississippi and wanted to extend its authority over the whole Mississippi Valley. France, reluctant to see a strong American power, inclined toward the Spanish view.

HOWE'S HAM AND CLARET BRING NO PEACE

Lord Howe tried to end the Revolution at this luncheon in Billop House, Staten Island, Sept. 11, 1776, but Benjamin Franklin, John Adams, and Edward Rutledge would accept no terms but American independence, so the war dragged on.

The United States possessed a strong claim. Before and during the Revolution American settlements had been made in Kentucky and Tennessee. Virginia considered the Kentucky settlements one of its counties, and North Carolina held the same view of the Tennessee settlements.

These lands were won for the United States by George Rogers Clark in 1778–79 (*see* Clark). Clark, a 25-year old Virginian, had persuaded Patrick Henry, governor of Virginia, to authorize an expedition. Clark raised a force of 175 men and struck westward. During the summer of 1778 he took the three British posts of Vincennes, Cahokia, and Kaskaskia. At Kaskaskia he negotiated treaties of peace with the Indian allies of the British.

In midwinter, Clark learned that the British governor at Detroit had marched southward and retaken Vincennes. Although the 180 miles that lay between Kaskaskia and Vincennes were covered with snow and broken by ice-filled swamps and streams, Clark gathered a small force and struck eastward. On Feb. 23, 1779, Clark's 130 men reached the Wabash River. Under cover of night they surrounded the British fort and opened fire. The British surrendered the next day.

The Peace Treaty

Fearing (not without reason) that Spain and France were ready to betray the United States, Adams and Jay outvoted Franklin, decided to ignore the French alliance, and negotiated a preliminary peace treaty with England, which was signed at Paris, Nov. 30, 1782. The Americans secured their independence and the land west to the Mississippi. They were also allowed to fish in the waters off Newfoundland, but not to dry or cure their catches on the island. Under the treaty Congress agreed to recommend to the states that they compensate the Loyalists for property taken from them during the war, and no laws were to be passed to prevent the payment of debts which Americans owed to British merchants. The boundary on the north included the line of the Great Lakes, and the citizens of both the United States and Britain were to have the right to use the Mississippi River. France acted with good nature in accepting this treaty, which was made final by the Treaty of Paris, Sept. 3, 1783. On the same day a general peace was concluded between England and her European foes.

The American Revolution was a great social movement tending toward democracy and equality. Thousands of Loyalists had fled from the 13 states to Canada. Remembering how harshly they had been treated by the patriots, they strengthened the earlier determination of the Canadians to hold aloof from the United States. Vast estates of land had passed from the king, from the colonial proprietors (in Pennsylvania and Maryland), and from Loyalists into the hands of the new state governments. These estates were now broken up into small tracts and distributed among the people at a low cost, or given to patriot soldiers as a reward for military service.

For a century thereafter, the United States was to be a nation of small farm owners, each enjoying the fruits of his labor and recognizing no overlord save the government. The barriers that had checked the westward movement were broken down, and a flood of settlers sought the lands beyond the mountains. State governments had been erected; the first experiment in national union was in progress (*see* Articles of Confederation; United States Constitution).

REYMONT, LADISLAS (1868–1925). As a young man, Ladislas Reymont roamed his native Poland, shifting from job to job. He learned to know especially the way the farmers lived, their customs, and their deep love of the land. Out of this experience he wrote 'The Peasants', a novel which won him the Nobel prize for literature in 1924.

Reymont was born in the village of Kobelie Wielkie in the Russian-Polish province of Piotrkow in 1868. (His name in Polish is spelled Wladyslaw Stanislaw Rejment.) His father, the village organist, struggled to support the family of ten children. They lived on a poor farm at the edge of town, and the boy went

to the village school. He read constantly but he was not a good student.

After grammar school he took the entrance examinations for the secondary school at Lodz, but failed. He was expelled from other schools and was finally apprenticed to a tailor. He quit that trade after four years and took job after job, never staying long at anything. Among other things he was a member of a touring theatrical company, a novice in a monastery, and supervisor of a railroad construction gang.

All this time he continued his reading, and by 1893 he decided to make writing his career. He went to Warsaw and began writing short stories. Success came slowly, but he earned enough from the stories to begin a novel. This was 'A Pilgrimage to Bright Mountain' (1895) based on scenes he had witnessed at the monastery. 'The Comedienne' (1896) told of his experiences with the traveling actors.

In 1902 Reymont began 'The Peasants.' He divided it into four volumes—'Autumn,' 'Winter,' 'Spring,' 'Summer.' The work took him seven years to write. It won him a world reputation, for it told in realistic detail how the Polish peasant lives close to the land and how the weather and the changes in the four seasons guide his daily life. Reymont's later books were less notable.

REYNOLDS, SIR JOSHUA (1723–1792). Not all artists have great difficulties and die unknown and unrewarded. Sir Joshua Reynolds became England's most successful portrait painter and gained riches as well.

FROM THE BRUSH OF AN 18TH-CENTURY MASTER

Above is Sir Joshua Reynolds' portrait of 'Mrs. Siddons as the Tragic Muse', often regarded as his greatest painting. The sitter was Sarah Siddons, a noted tragic actress of the British stage. Her pose suggests a scene from Greek tragedy. At left is a self-portrait of Reynolds, one of 16 he painted of himself over several years.

Reynolds' birthplace was Plympton Earle in Devonshire. His father, a clergyman, conducted a grammar school, and the boy was one of his pupils. Young Reynolds preferred sketching on the margins of his Latin exercises to Latin itself, and he copied drawings at every chance. At 17 he was apprenticed to Thomas Hudson, a popular London portrait painter. Reynolds studied with him for two years. The next several years he divided between Plymouth and London.

At Plymouth Reynolds met Lord Edgecumbe, who became a life long patron. Edgecumbe introduced him to Captain Keppel, commander of the Mediterranean squadron of the British fleet. Keppel gave him passage to Rome and there for two years Reynolds studied the Italian masters. There too Reynolds suffered one of the few hardships of his career. In the drafty galleries he caught a cold that led to permanent deafness.

In 1752 Reynolds returned to London and established himself as a portrait painter. Success came quickly. Nearly every well-known Englishman of the time sat for a Reynolds portrait. Reynolds became specially noted for his portraits of women and children. He never married, but maintained a splendid London house and was active in society. In 1764 he founded the Literary Club which had as members such famed writers as Samuel Johnson and Oliver Goldsmith and such statesmen as Edmund Burke and Charles James Fox.

In 1768 Reynolds became president of the newly founded Royal Academy, and the next year he was knighted by King George III. From 1769 through 1789 he delivered his 'Discourses' at each prize awarding

of the Academy. These lectures preserve Reynolds' ideas on the proper training of artists: learning to draw and to use color, studying masterpieces, and comparing these to nature. The 'Discourses' reflect the taste of his time, a balanced appreciation of earlier models and of nature, with subjects drawn from history and fable.

Reynolds' own portraits give his subjects an appearance of action although he posed them in attitudes that imitated his Italian masters. His use of vivid colors also reflect his study in Italy. Unfortunately many of his pictures have faded badly with time. He himself was far more original than the imitative standards he advocated in the 'Discourses'. Today his pictures hang in galleries all over the world.

RHEA. The ancient Greeks called Rhea the "mother of the gods." She was one of 12 giants—the Titans. Her father was Uranus, mythical first ruler of the universe. Her mother was Gaea, the goddess of the earth. Rhea's Titan brother, Kronos, usurped his father's throne, and so became ruler of the universe. He then married Rhea. Their mother prophesied that a child born of this marriage would overthrow Kronos, as Kronos had overthrown his father.

Rhea bore five children: Hades, Poseidon, Hera, Hestia, and Demeter. Kronos swallowed each one for fear that Gaea's prophecy would come true. Before her sixth child was born, Rhea fled to a cave in Crete. There she gave birth to Zeus and hid him from Kronos When Kronos demanded to see his child, Rhea handed him a stone wrapped in swaddling clothes. Kronos swallowed this, thinking it was the baby.

Rhea left Zeus in Crete, appointing the Curetes (*kū-rē'tēz*), earth-born demons, to look after him. The Curetes wore bronze armor. When the baby cried they beat their spears against their shields to drown out the noise so that Kronos would not hear it. After Zeus was grown he compelled Kronos to give up the children he had swallowed. They joined forces to overthrow their father and divided his power among themselves (*see* Uranus; Zeus).

This legend gave rise to ancient festivals held in honor of Rhea on the island of Crete. At these, priests called Curetes, wearing armor, danced furiously to the music of flutes, cymbals, and drums.

The "great mother" goddess of Asia Minor was Cybele (*sĭb'ĕ-lē*). So Cybele and Rhea became identified. People worshiped Cybele primarily as goddess of nature and reproduction and secondarily as goddess of agriculture and social progress. In the second rôle she was the founder of cities, and artists pictured her wearing a crown of little towers. Legend said that Cybele was attended by Corybantes (*kŏr-ĭ-băn'tēz*), demigods similar to Rhea's Curetes. Consequently priests of Cybele called themselves Corybantes.

THE "AMERICAN OSTRICH"

This is the common rhea. It is smoke-gray. The top of the head and lower part of the neck are blackish. There are two black crescents on the breast.

RHEA. The South American bird known as the rhea is almost as strange-looking as its African cousin, the ostrich. But the rhea is not nearly so tall and is therefore not so ungainly. Its feathers are smooth and flat, not curly like those of the ostrich. The rhea differs from the ostrich in other ways. It has almost no tail, its neck and upper legs are feathered, and it has three toes.

The rhea is the largest bird of the western hemisphere. Its wings are poorly developed. It cannot fly, but it can outrun any animal native to its region The structure of its wings suggests that its ancient ancestors were flying birds.

Rheas roam the grasslands of South America from central Brazil to southern Argentina. They are especially numerous in the pampas of sparsely settled Matto Grosso. At one time rhea feathers were popular for the manufacture of feather dusters. Hunters slaughtered the birds to meet the demand. As a result they are not so plentiful as they were.

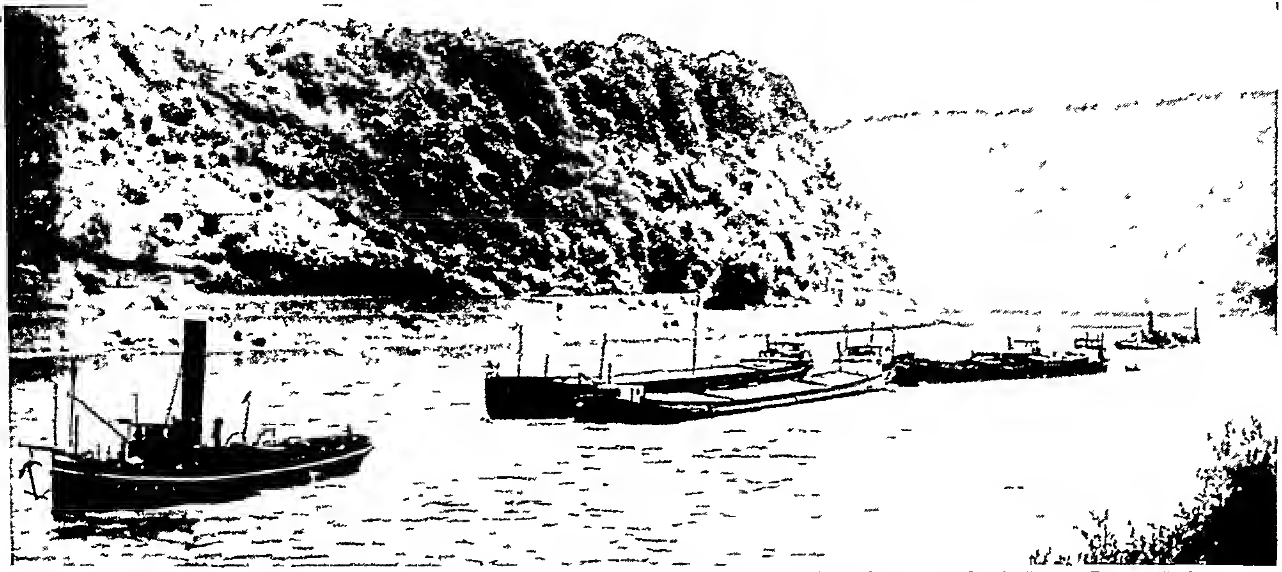
Rheas usually associate in flocks of one male and several females. The nest is a wide depression in the ground, lined with leaves and grass. The females of the group all lay their eggs in the same nest When they are through laying, the nest contains from 30 to 60 large creamy-white eggs. Members of the flock take turns looking after the nest. Those not on duty at the nest range far and wide over the pampas, feeding on berries and herbs.

Popular names for the rhea are American ostrich and nandu. Scientific name for the common rhea, *Rhea americana*. Order, *Rheidae;* superorder, *Palaeognathae.*

RHETORIC (*rĕt' ô-rĭk*). Grammar teaches the proper uses of words and how to combine them correctly into sentences. Rhetoric also teaches us to speak and write not only correctly but *effectively*—so as to produce a desired impression upon a reader or hearer. Grammar says, "This is right, that is wrong." Rhetoric says, of several different ways of putting an idea, "*This* is the best way to convey the thought." Rhetoric seeks not only correctness, though this is of course the first essential, but also *clearness*, *unity*, *force*, and *beauty* in expression.

Rhetoric was first taught by the ancient Greeks and meant originally the art of the orator, of speaking

THE MIGHTY RHINE—EUROPE'S CHIEF COMMERCIAL RIVER



Night and day sturdy tugs tow strings of heavily loaded barges up and down the Rhine from the North Sea to Basel, Switzerland. Many self-propelled barges are now entering this freight service. The barges above are sailing between the steep, wooded banks of the middle course of the Rhine. So important is the Rhine to Europe's commerce that it was internationalized in 1868.

to persuade or move others. In the 4th century B.C. the philosopher Aristotle embodied the Greek rules and experience in a treatise on rhetoric which has never been surpassed (*see* Aristotle). In it he urged particularly that no tricks of expression can take the place of sound reasoning, and that true beauty and power to persuade go hand in hand with sincerity. Disregard of these principles has led to occasional use of the term "rhetoric" to mean an insincere, windy, and tricky expression as a substitute for merit.

In later times, especially since the invention of printing, writing has come to be more important than oratory. Rhetoric has become concerned more with the art of writing than with that of speaking; but it is well to remember its connections with oratory. If in writing we put ourselves in the place of the orator, who must so express himself that his message will strike home to his audience, we shall write more clearly and more suitably. We shall be less likely to make such bad mistakes as using flowery, poetic language in a business letter or using colloquial language in an essay on a lofty subject.

Important as is the study of the rules and principles of rhetoric, no one claims that this study alone will make a writer. "Learning by doing" is a safe motto in this as in everything else, and practice is of the first importance. Hence writing is taught in schools and colleges largely by having students write "themes," and then using the principles of rhetoric as a guide for correcting mistakes and improving the students' style. (*See also* Figures of Speech.)

RHINE RIVER. The Rhine is Europe's busiest river. It is only about 850 miles long, but it flows through the most thickly populated part of the continent. Rhine steamers and barges carry an almost constant flow of cargoes for the people of western Europe.

The Rhine (*Rhein* in German) rises in the Alps and empties into the North Sea. It begins in east-central Switzerland at the juncture of two small mountain streams, the Vorder Rhein and Hinter Rhein. They rise at more than 7,000 feet and meet near Chur. Their combined flow, now called the Rhine, sweeps north to form a border between Switzerland, Liechtenstein, and Austria. The Rhine then turns west through Lake Constance, north again to form the border between France and Germany, then west through the Netherlands. There it branches into many arms, which form a wide, flat delta on the coast of the North Sea.

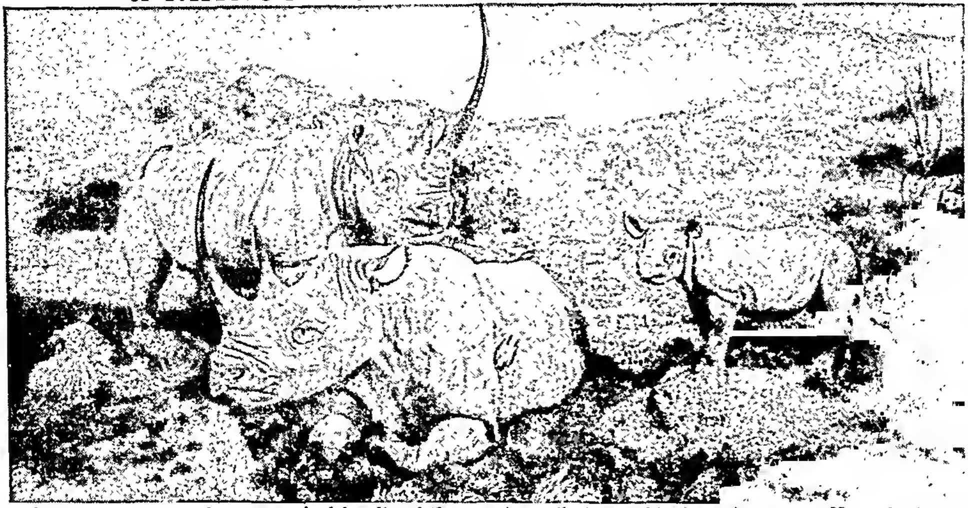
The course of the Rhine is divided into three parts—the upper, middle, and lower Rhine. The upper Rhine extends from its Alpine headwaters to Basel; the middle runs through a narrow, largely rural valley from Basel to Cologne; the lower, through the great plain from Cologne to the North Sea. The German part of this plain is thronged with industrial cities.

From earliest times the Rhine has been an avenue of conquest and trade. Even prehistoric people followed its course. Later it became the frontier of the Roman Empire and then the gateway for the onrushing Teutonic barbarian tribes (*see* Germany, section on history). In the Middle Ages the Rhine was the great route for the rich overland trade between central Europe, Italy, and the Orient.

Today canals link the Rhine with the Rhone, the Marne, the Danube, the Ems, and many other navigable rivers. These canals provide water transportation to every port of Germany, to France, Belgium, and the Netherlands. An important link is the Rhine-Herne canal, which joins the Rhine to the coal fields and industries of the Ruhr basin, the chief manufacturing center of Germany and of all Europe.

The Rhine gives Switzerland a "seaport," for Basel is the head of the river's navigation. Barges up to 1,200 tons sail from North Sea ports to Basel, carrying the raw materials the Swiss need for their fine

A RHINOCEROS FAMILY OF EAST AFRICA



This museum group shows a typical family of the species called the "black" rhinoceros. Note the long, deadly horns with which the parents guard the young one. On the resting rhinoceros are perched two tick birds. They befriend the huge beasts by eating the tiny ticks that creep into the folds of their skin.

manufactures. Barges up to 4,000 tons can haul cargoes up the Rhine as far as Cologne. In normal years the Rhine carries over 80 million tons of cargo, chiefly Ruhr coal, iron ore, petroleum, and grain.

The upper and middle Rhine have majestic beauty. Magnificent falls on the upper Rhine near Schaffhausen power a large Swiss aluminum plant. The middle Rhine, which cuts an 80-mile gorge from Bingen to Bonn, is especially dear to the German people. Many of their legends arose from its wooded banks, such as 'Song of the Lorelei' and 'Nibelungenlied' (*see* Heine; Nibelungs). Splendid castles rise on the rocky heights, many of them the old strongholds of medieval robber barons. Among the most famous are the castles of Rheinstein (Rhine stone), Rheinfels (Rhine rock), and Drachenfels (Dragonrock).

RHINOC'EROS. Through eastern Africa from Ethiopia south into Transvaal, lumber *common* or *black rhinoceroses.* They weigh from 2,500 to 5,000 pounds. Some grow ten feet long and stand five and one-half feet tall at the shoulder.

As the upper picture shows, the black rhinoceros has two horns. The front one grows 18 to 40 inches long. Another remarkable feature is the pointed upper lip that grasps and picks up small objects almost as deftly as a hand. The eyes are small and short-sighted, but the nostrils and the ears are large and very keen. Even a lion's teeth can scarcely dent the thick, loose-fitting hide. Though it may look black in jungle shadows, the hide is actually a slate gray that gains a brown tinge when the animal sweats.

INDIAN RHINOCEROS

The horn is not of bone, but consists of hair fibers growing from the skin, cemented into a tough mass.

The feet resemble an elephant's, but have only three toes.

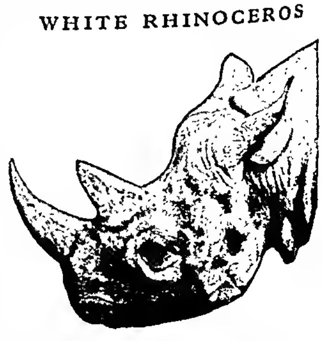
Black rhinoceroses usually live alone or in trios—a bull, a cow, and their calf. The cow bears only one calf about every three years, and both parents guard it jealously. They teach it to grasp and pick with its upper lip the things they have found so delicious—leaves, fruit, and twigs. Also they show it how to dig out nourishing roots with its growing front horn. All the while the family members chat squeakily in birdlike "tweets."

But they stop at the dimmest scent or sound of an enemy. The parents may flee with the calf deep into the forest. Or they may snort like locomotives, and with horns pointing straight ahead charge their enemies at 25 to 35 miles an hour. The front horn goes straight through any hunter who fails to leap aside.

In Africa lives only one other species, the *white* or *square-mouthed rhinoceros* of Uganda and Zululand. Fourteen feet long, six and one-half feet tall at the shoulder, and weighing over 6,000 pounds, it ranks with the hippopotamus as the largest living land mammal next to the elephant. From the snout tower two great horns, the front one from 30 to 60 inches long. Grass is the chief food of this rhinoceros, for its upper lip is straight-edged and cannot pick up twigs and leaves. The hide is light slate gray, reddened by sweat.

All of the other three species living today occur in Asia. The rare *Indian rhinoceros* roams the Assam plains. It has but one horn, about a foot long. Though it resembles the black rhinoceros in size, disposition, and diet, it has many more and far deeper creases in its hide. Indeed, it looks like an armor-plated monster. The somewhat smaller *Javan rhinoceros,* also with one horn and an armor-plated body, lives in the forests of the East Indies, the Malay Peninsula, Burma, and Bengal. Often it can be tamed for natives to ride. Smallest of all is the *Sumatran rhinoceros* that rarely reaches a ton in

WHITE RHINOCEROS



This is a young specimen of the white or square-mouthed rhinoceros, with its two half-grown horns.

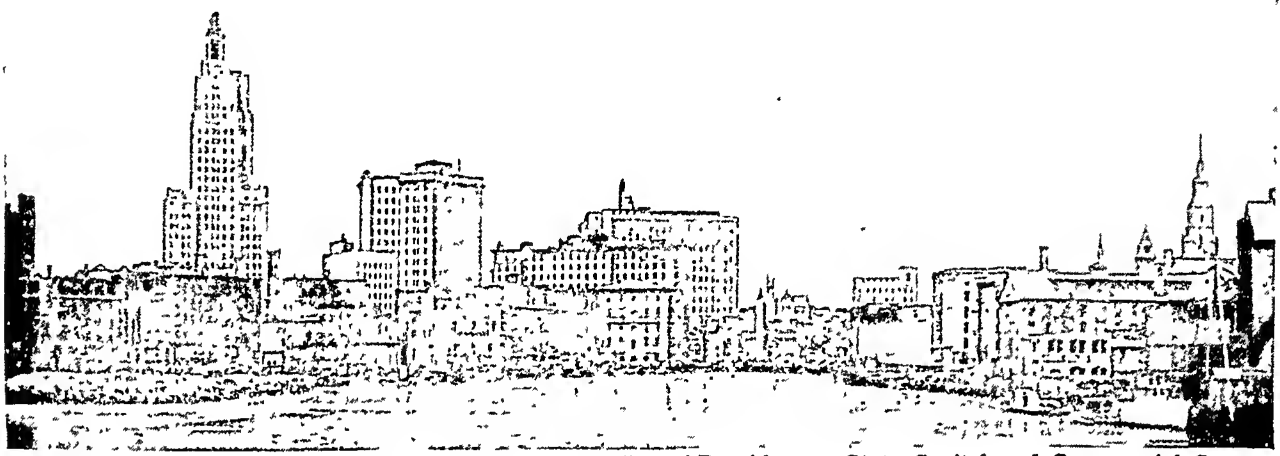
weight. It is two-horned, with a granular hide. Its range is the same as that of the Javan rhinoceros, except that it does not live in Java.

Prehistoric rhinoceroses roamed North America, Europe, and northern Asia. Many lived in what is now Colorado, Nebraska, Wyoming, South Dakota, and North Dakota. From Siberian ice cliffs have been recovered the carcasses of huge two-horned *woolly rhinoceroses* that lived at the time of the mammoths.

Hunters have killed so many rhinoceroses that zoos can obtain few living specimens. In Africa they are caught by shooting the mother and roping the young one. Indian rhinoceroses have been trapped in pits cleverly concealed by boughs and branches.

The rhinoceros belongs to the family *Rhinocerotidae* of the order *Perissodactyla* (odd-toed hoofed animals) which includes also the horses and tapirs. The name *rhinoceros* comes from the Greek words *rhinos* for "nose" and *keras* for "horn." Scientific name of common or black rhinoceros, *Diceros bicornis;* of white or square-mouthed rhinoceros, *Diceros simus;* Indian rhinoceros, *Rinoceros unicornis;* Javan rhinoceros, *Rhinoceros sondaicus;* Sumatran rhinoceros, *Dicerorhinus sumatrensis;* extinct woolly rhinoceros, *Coelodonta antiquitatus* or *Rhinoceros antiquitatis.*

"LITTLE RHODY" *and Its* BUSY INDUSTRIES



Across the Harbor on Narragansett Bay Appears the Skyline of Providence—State Capital and Commercial Center

RHODE ISLAND. If the land area of the United States were divided into states the size of Rhode Island, there would be the astonishing number of 2,814 states instead of the present 48. But Rhode Island makes up for being the smallest state in the Union by also being the most thickly populated. The average for the entire state is about 748 persons to the square mile. The density of population is 15 times that of Florida, with about 51 persons to the square mile (about the average for the entire United States). Almost all the people live in cities and towns. This population can be supported because Rhode Island is a busy manufacturing and commercial state—the most highly industrialized state in the Union.

Despite its size, Rhode Island has played an important rôle in American history. More than 300 years ago Roger Williams and Anne Hutchinson came to this area to establish settlements where they could have the religious freedom that they had been denied in Massachusetts. Rhode Island also became a refuge for those who were seeking the freedoms of speech, press, and assembly. Rhode Island's colonial charter of 1663 guaranteed citizens many of the freedoms which were later written into the Bill of Rights of the American Constitution.

The Beginning of the Industrial Revolution

Rhode Island is sometimes called the cradle of the Industrial Revolution in America. In 1789 Samuel Slater came from England to Pawtucket. Here he designed a water-driven spinning frame and set up the first machine-equipped mill in the New World (*see* Industrial Revolution). It turned out a strong-warp cotton yarn.

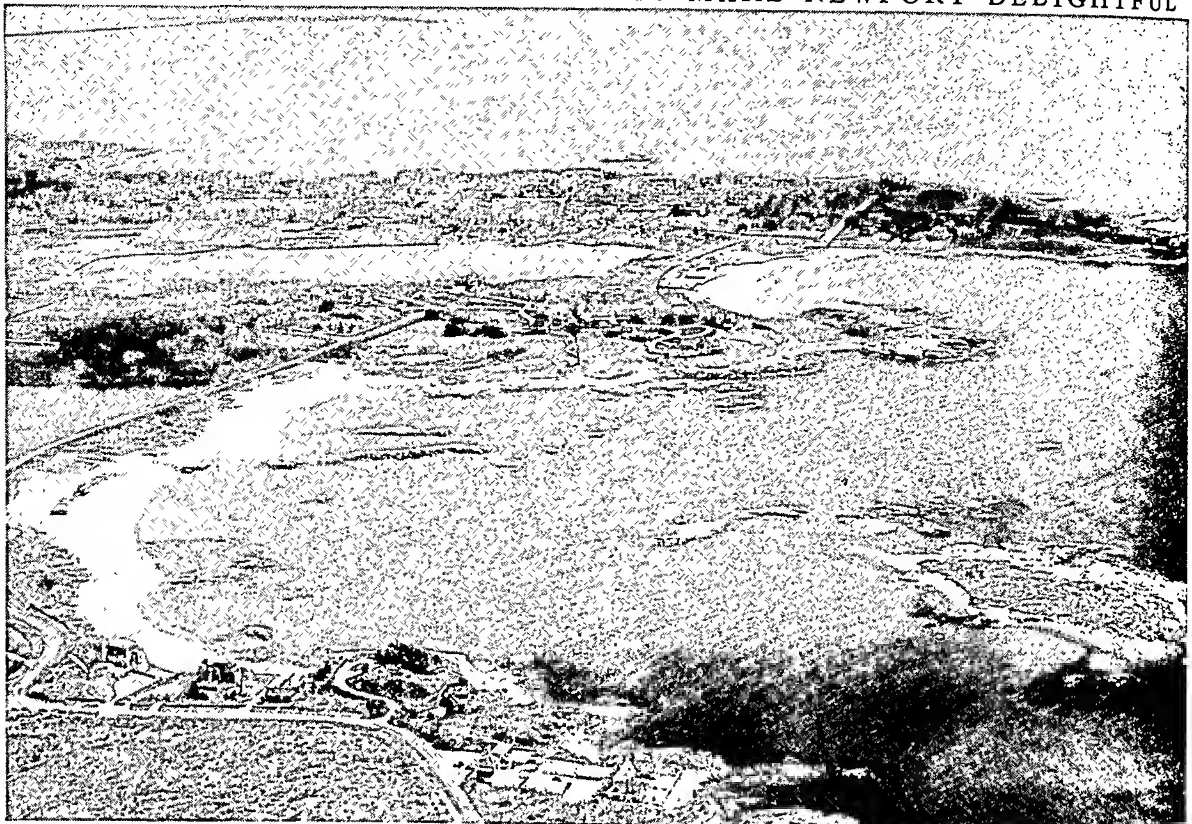
Today, although much of the cotton industry has moved to the Southern states, Rhode Island still produces large quantities of cotton textiles, which are noted for their quality, color, and design. The manufacture of woolen and worsted goods has now far surpassed cotton in value, however, and there are also large silk and rayon mills.

The Lay of the Land

The states of Massachusetts and Connecticut border Rhode Island. Its southern coast line on the Atlantic Ocean is only 54 miles long. But this coast line is increased to some 330 miles if the shores of the many bays, coves, and outlying islands are counted. Narragansett Bay, for example, cuts deeply (28 miles) into the eastern part of the state. The most important islands in the waters of the bay are Rhode (from which the entire state gets its name), Prudence, Conanicut, Dutch, and Patience. Ten miles off the coast lies Block Island, a busy fishing center.

Westward from Point Judith, in the center of the Atlantic coast line, are many peninsulas, sandy beaches, and sand shoals, cut off from the mainland by shallow salt ponds. The coastal plain of the state is generally low, but the central and northern parts are rocky and hilly. There are no real mountains in the state. The land rises from sea level to an elevation of 200 feet on the coastal plain and to about 800 feet

WATER, SUN, AND SUMMER BREEZES MAKE NEWPORT DELIGHTFUL



The blue waters of Narragansett Bay lap the white beaches of Newport. This Fairchild Aerial Survey photograph shows how the land rises gently from sea level to a broad plateau with an elevation of about 100 feet. On this plateau and on the slope to the bay are the summer estates of many wealthy families. These estates have fine homes, gardens, and private beaches.

in the northwest, where the hills are rugged and covered with trees.

The streams of Rhode Island are small and swift. Before coal was widely used for power, they turned the wheels of the state's mills and factories. There are many small lakes and ponds in the state, scooped out by glaciers thousands of years ago. Today these lakes are popular summer resorts for bathing, fishing, and boating. Almost 70 per cent of the state is forested. The chief trees are maple, ash, oak, birch, willow, elm, and pine. The state has much wild life and small game birds and animals.

Scattered throughout their state, which the residents proudly call "Little Rhody," are 30 state parks. Many of these popular parks are well-developed recreational centers. Rhode Island is even better-known for its many fine bathing beaches. During the summer, towns, hotels, and houses from the oldest resort of Newport to Block Island and Narragansett Hill are crowded with visitors. In Narragansett Bay there is deep-sea fishing and sailing. Rhode Island boasts the first public skating rink in the United States, and the first world championship baseball game, first national open golf tournament, and first international polo contest.

The People of the State

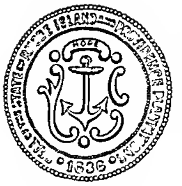
The number of foreign-born residents has been decreasing. Today most of the people are native born. Of all immigrants to the state since it was formed, the largest group came from Scotland and Ireland. Other large groups were made up of French-Canadians and Italians. Most of the earlier immigrants worked in the state's textile mills. Later arrivals and many of the descendants of the older-stock immigrants found occupation in retail and wholesale trade as well as in such professions as law and medicine.

The peoples who came to Rhode Island brought with them many of the customs and traditions of their homelands. The earliest settlers told, heard, and even believed folk tales and witch stories. Some of these came from the old country; others were based upon Indian legends. Newcomers also introduced many homeland celebrations. The Italians and Portuguese hold their own yearly festivals, including the Queen's Birthday and the Feast of the Holy Ghost. Many residents enjoy old-fashioned clambakes and oyster-opening contests, for which the state is well-known. Although many of the old pastimes have given way to more modern amusements, enough of them remain to give Rhode Island a truly distinctive character.

Because of the large numbers of Italians, Irish, French-Canadians, and Poles, the Roman Catholic Church has the largest membership in Rhode Island. Other important denominations are the Episcopal,

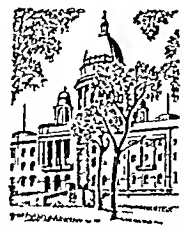
Continued on page 142

Rhode Island Fact Summary

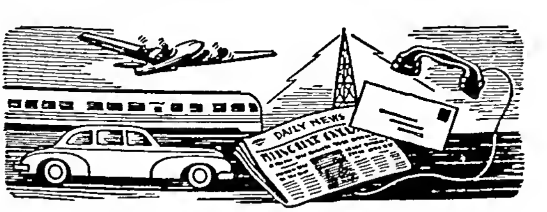


RHODE ISLAND (R.I.): Named for Rhode Island in Narragansett Bay. The island's name probably from Greek *rhodos*, meaning "roses"; or from Dutch *Roode Eylandt* (Red Island) for clay along island's shores.
Nickname: "Little Rhody."
Motto: Hope.
Seal: Small scroll bears the state motto. Below it is an anchor and the date 1636.
Flag: For description and illustration, *see* Flags.
Flower (unofficial): Violet. **Bird (unofficial):** Bobwhite. **Tree (unofficial):** Maple. **Song:** 'Rhode Island', words and music by T. Clarke Brown.

THE GOVERNMENT



Capital: Providence (since 1900; jointly with Newport 1854–1900).
Representation in Congress: Senate, 2; House of Representatives, 2. Electoral votes, 4.
General Assembly: Senators, 44; term, 2 years. Representatives, 100; term, 2 years. Convenes first Tuesday in January each year. Legislators paid for not more than 60-day session; no limit to session length.
Constitution: Adopted 1842. Proposed amendments must be (a) passed by a majority of elected members of two successive general assemblies and (b) passed by three-fifths voting on amendment at town meetings.
Governor: Term, 2 years. May succeed himself.
Other General Officers: Lieutenant governor, secretary of state, attorney general, general treasurer, all elected; terms, 2 years.
Judiciary: Supreme court—5 justices, elected by Grand Committee (Senate and House sitting together); hold office until declared vacant by General Assembly. Superior court—11 justices, appointed by governor with consent of Senate; hold office during good behavior. District courts—12; 13 judges appointed by governor with consent of Senate; term, 3 years.
County: 5 counties; no county government.
Municipal: 7 cities—3 have mayor-council; 3 have mayor, common council, board of aldermen; 1 has mayor, representative council, board of aldermen. Towns each governed by a president and town council.
Voting Qualifications: Age, 21; residence in state, 1 year; in town or city, 6 months.

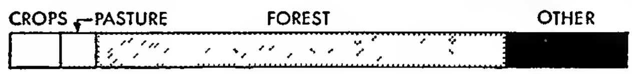


TRANSPORTATION AND COMMUNICATION

Transportation: Railroads, 200 miles. First railroad, Providence to Boston (in Rhode Island, from East Providence across Seekonk River), 1835. Rural roads, 1,700 miles. Airports, 10.
Communication: Periodicals, 13. Newspapers, 23. First newspaper, *Rhode-Island Gazette*, Newport, 1732. Radio stations (AM and FM), 16; first station, WEAN, Providence, licensed June 5, 1922. Television stations, 1; WJAR-TV, Providence, began operation July 10, 1949. Telephones, 268,600. Post offices, 70.

THE PEOPLE AND THEIR LAND

Population (1950 census): 791,896 (rank among 48 states—36th); urban, 84.3%; rural, 15.7%. Density: 748.5 persons per square mile (rank—1st state).
Extent: Area, 1,214 square miles, including 157 square miles of water surface (48th state in size).
Elevation: Highest, Jerimoth Hill, in Foster Township, 812 feet; lowest, sea level.
Temperature (°F.): Average—annual, 50°; winter, 31°; spring, 46°; summer, 68°; fall, 53°. Lowest recorded, −23° (Kingston, Jan. 11, 1942); highest recorded, 102° (Greenville, July 30, 1949, and other locations and earlier dates).
Precipitation: Average (inches)—annual, 43; winter, 11; spring, 11; summer, 10; fall, 11. Varies from about 50 inches in south to about 39 inches in northeast.
Natural Features: Rough and hilly except sand-plain lowlands near the Atlantic Ocean and Narragansett Bay. North and west of coastal plain land rises sharply to 812 feet in Foster Township. Principal rivers: Blackstone, Pawcatuck, Pawtuxet, Providence.
Land Use: Cropland, 8%; nonforested pasture, 6%; forest, 66%; other (roads, parks, game refuges, wasteland, cities, etc.), 20%.



Natural Resources: *Agricultural*—variable soil throughout state makes for diversified, small-scale farming; Narragansett Bay area most fertile. *Industrial*—granite, important bedrock resource, valuable for monuments and building purposes. *Commercial*—waterways, abundant water power; Narragansett Bay valuable for transportation, fisheries, and recreational facilities.

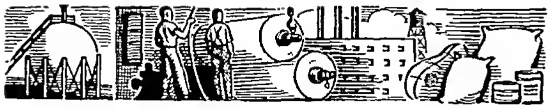
OCCUPATIONS AND PRODUCTS

What the People Do to Earn a Living

Major Industries and Occupations, 1950

Fields of Employment	Number Employed	Percentage of Total Employed
Manufacturing	133,975	44.1
Wholesale and retail trade	54,479	17.9
Professional services (medical, legal, educational, etc.)	23,831	7.8
Transportation, communication, and other public utilities	17,163	5.6
Construction	16,810	5.5
Government	15,968	5.2
Personal services (hotel, domestic, laundering, etc.)	14,150	4.6
Finance, insurance, and real estate	9,314	3.1
Business and repair services	6,420	2.1
Agriculture, forestry, and fishery	5,246	1.7
Amusement, recreation, and related services	2,817	0.9
Mining	175	0.1
Workers not accounted for	4,164	1.4
Total employed	304,512	100.0

Rhode Island Fact Summary



What the People Produce

A. Manufactured Goods (Rank among states—29th)
Value added by manufacture* (1952), $724,446,000

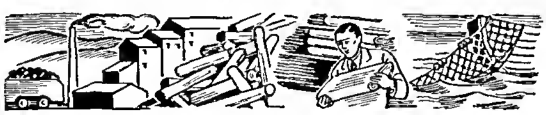
Leading Industries in 1947 (with Principal Products)	Value Added by Manufacture	Rank among States
TEXTILE MILL PRODUCTS......... Woolen and worsted fabrics; cotton and rayon broad-woven fabrics; woolen-yarn mills; finishing textiles; narrow-fabric mills	$282,164,000	8
MISCELLANEOUS MANUFACTURES... Jewelry and silverware; costume jewelry	98,206,000	8
MACHINERY (EXCEPT ELECTRICAL) . Machine tools; textile machinery	69,170,000	16
FABRICATED METAL PRODUCTS .... Cutlery, hand tools, and hardware; miscellaneous products, such as screws, bolts, nuts, and rivets	38,246,000	20
PRIMARY METAL INDUSTRIES...... (Such as copper rolling and drawing; gray-iron foundries; wire drawing, etc.)	28,568,000	24

*For explanation of value added by manufacture, *see* Census.

B. Farm Products (Rank among states—48th)
Total cash income (1952), $27,558,000

Products	Amount Produced (10-Year Average)	Rank within State*	Rank among States†
Milk..........	62,000,000 qts.	1	47
Eggs... ..	7,000,000 doz.	2	46
Potatoes	1,263,000 bu.	3	43
Chickens . .	6,028,000 lbs.	4	45
Hay. .	50,000 tons	5	48

*Rank in dollar value †Rank in units produced



C. Fish (Rank among states—21st)
(Marine waters and coastal rivers, 1950), catch, 38,265,000 lbs.; value, $2,788,000

D. Minerals (Fuels, Metals, and Stone)
Annual value (1951), $1,278,000
Rank among states—47th

Minerals (1951)	Amount Produced	Value
Stone	239,000 tons	$652,000
Sand and gravel...	535,000 tons	577,000

E. Trade

Trade (1948)	Sales	Rank among States
Wholesale.......	$722,552,000	38
Retail...	716,064,000	36
Service......	72,478,000	34

EDUCATION

Public Schools: Elementary, 292; secondary, 62. Compulsory school age, 7 through 16. Under administration of commissioner of education, appointed by the state board of education. City and town boards of education are elected by popular vote. The town superintendents of schools are appointed by the school committees.

Private and Parochial Schools: 110.

Colleges and Universities (accredited): 11. State-supported schools include Rhode Island College of Education, Providence; University of Rhode Island, Kingston.

Special State Schools: Rhode Island School for the Deaf, Providence; Exeter School (for mentally deficient), Lafayette; State Home and School (for homeless and underprivileged), Providence.

Libraries: City and town public libraries, 73. State library responsible for aid in developing library service. Noted special libraries: Providence Athenaeum, Annmary Brown Memorial, John Carter Brown and John Hay (Brown University), all at Providence.

Outstanding Museums: Varnum House and Military Museum, East Greenwich; South County Museum, North Kingston; Museum of Art of R. I. School of Design, Park Museum, and R. I. Hist. Society, all at Providence.

CORRECTIONAL AND PENAL INSTITUTIONS

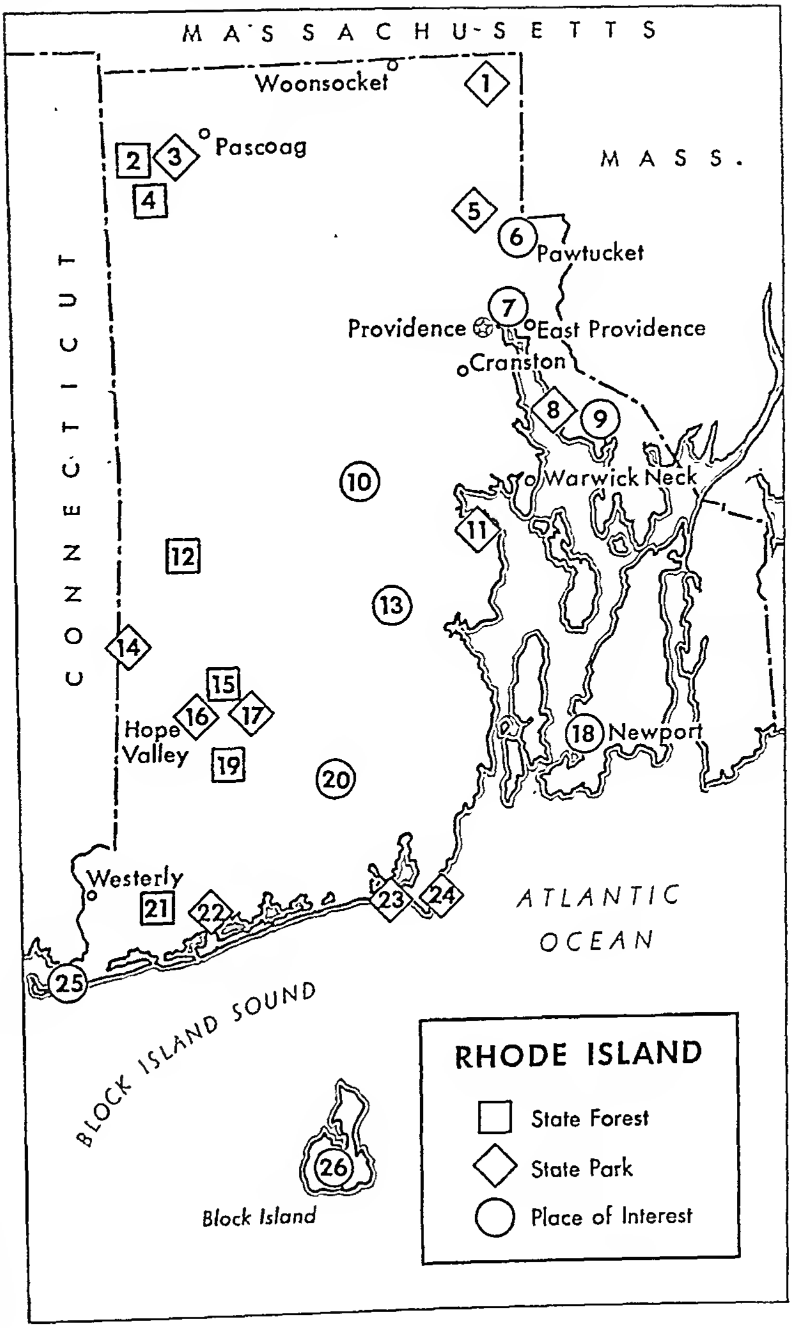
Rhode Island Training School for Girls, Rhode Island Training School for Boys, State Reformatory for Men, State Reformatory for Women, State Prison, all at Howard.

PLACES OF INTEREST*

Cliff Walk—originally fisherman's trail, ocean-shore footpath bordering luxurious Newport estates (18).
Daggett House—Pawtucket; now a museum (6).
First Baptist Meeting House—at Brown University, Providence; scene of commencements since 1775 (7).
Gilbert Stuart House—North Kingstown; birthplace of the famous portrait painter (13).
Martin's Ferry—established 1701 at Barrington Bridge; named for Luther Martin who received pay from state for ferrying troops on Muster Day, October 1798 (9).
Narragansett Park—race track in Pawtucket (6).
Nathanael Greene Homestead—Anthony; home of Revolutionary War general; built in 1770 (10).
Newport—famous resort of the wealthy; The Breakers and other mansions; Wanton-Lyman-Hazard House; 5 beaches; *see also* other places in this list keyed to (18).
Old Colony House of Newport—erected 1739; originally used by General Assembly; acceptance of Declaration of Independence officially proclaimed here (18).
Old Slater Mill—erected 1793 in Pawtucket; contains old spinning machines built by Samuel Slater, founder of cotton textile industry in America (6).
Providence—State Capitol (*see* Providence); *see also* other places in this list keyed to (7).
Queen's Fort—North Kingstown; authentic Indian fort; abandoned 1676 by Narragansett Indians after attack by colonial soldiers during King Philip's War (13).
Roger Williams Park—Providence; 453 acres set aside as memorial to founder of Rhode Island (7)
Settlers' Rock—Block Island; huge field stone engraved with names of first settlers (26).

*Numbers in parentheses are keyed to map.

Rhode Island Fact Summary



Site of Great Swamp Fight—1675; soldiers from southern New England colonies destroyed Narragansett Indian camp near present West Kingstown (20).

Site of Scamscamuck Spring—Barrington; said to be point from which all "bounds and limits" were made when Massasoit first sold lands to Pilgrims (9).

Stephen Hopkins House—completed 1755; Providence home of Stephen Hopkins, ten times governor; George Washington a guest here in 1776 and again in 1781 (7).

Touro Park—Newport; memorial to Judah Touro, donor to city; Old Stone Mill and a statue of Commodore Perry (18).

Touro Synagogue National Historic Site—Newport; also called Temple Jeshuat Israel (1763), probably oldest synagogue in America (18).

Watch Hill Lighthouse—light first shown in 1808; building replaced in 1858 (25).

STATE FORESTS*

Arcadia Area (Exeter Twp.)—7,634 acres (15).

Carolina Area (Richmond Twp.)—1,434 acres (19).

George Washington (Glocester Twp.)—244 acres (4).

Pulaski (Glocester Twp.)—3,061 acres (2).

Wickaboxet (W. Greenwich Twp.)—288 acres (12).

Woody Hill Area (Westerly Twp.)—723 acres (21).

STATE PARKS*†

Arcadia—forested area on Wood River; fresh-water bathing; picnicking (16).

Beach Pond—bird and plant sanctuary; fresh-water bathing; picnicking (14).

Burlingame—3,100 acres surrounding Watchaug Pond; wildlife sanctuary; fresh-water bathing; picnicking (22).

Dawley—woods and streams in hilly area; picnicking (17).

Diamond Hill—area mined in colonial days; in range of hills are Diamond Hill, which rises more than 640 feet, and Copper Mine Hill; ski tows, toboggan chute, and sled slide for winter sports; hardwood and conifer forests (1).

Goddard Memorial—forest area on a peninsula between Greenwich Bay and Potowomut River; salt-water bathing; bridle trails; golf course; picnicking (11).

Haines Memorial—on Bullocks Cove of Narragansett Bay; picnicking (8).

Lincoln Woods—officially named in 1909 on Lincoln's birthday; rock-strewn wooded hills surrounding Olney Pond; old houses and historic sites; Druid Circle of boulders; Goat Rock rises about 20 feet; Pulpit Rock; fresh-water bathing; bridle trails; picnicking (5).

Pulaski Memorial—fresh-water bathing; picnicking (3).

Sand Hill Cove Beach—a sand bar on the Atlantic Ocean with a half-mile-long beach, enclosed by Point Judith breakwater (23).

Scarborough Beach—south of Narragansett and near Point Judith entrance to Narragansett Bay; surf bathing on a fine beach along the Atlantic Ocean (24).

LARGEST CITIES AND TOWNS (1950 census)

Providence (248,674): state capital and important Atlantic port; manufactures textiles, machinery, tools, silverware, jewelry; site of Brown University.

Pawtucket (81,436): industrial city manufacturing textiles, machinery, tools, thread and yarn.

Cranston (55,060): textile mills; textile machinery.

Woonsocket (50,211): textile manufacturing center, producing woolens, worsteds, cottons, and rayons.

Warwick (43,028): textile printing and manufacturing.

Newport (37,564): U. S. naval base; famous resort.

East Providence (town) (35,871): baking-powder plant.

Central Falls (23,550): adjoins Pawtucket; textiles.

West Warwick (town) (19,096): fabrics, garments.

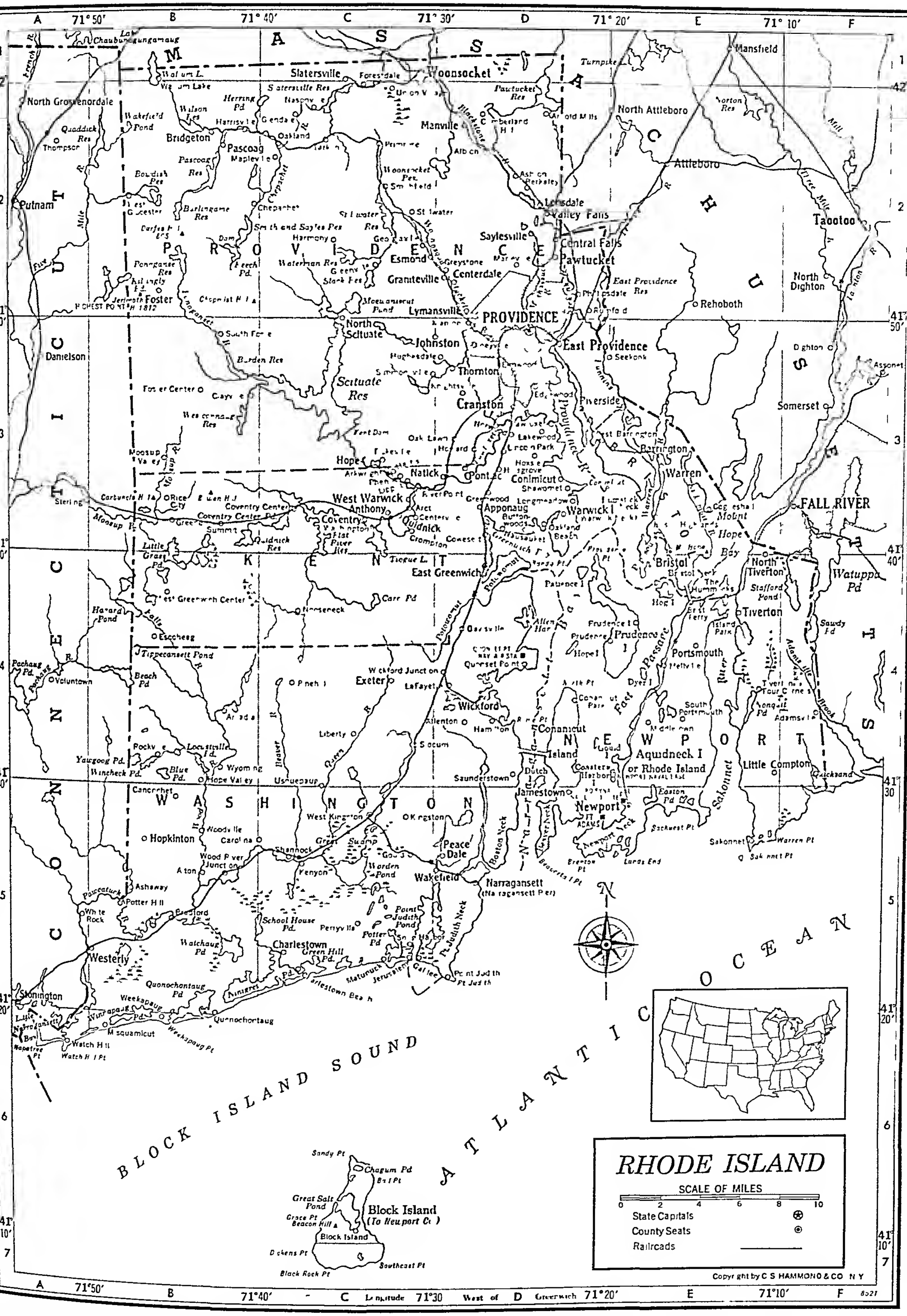
*Numbers in parentheses are keyed to map.

†There are 30 state parks; the 11 major parks are listed here; the remaining 19 parks have limited facilities.

Rhode Island Fact Summary

THE PEOPLE BUILD THEIR STATE

1524—Giovanni da Verrazano, Florentine in French hire, visits Narragansett Bay.
1614—Dutch captain Adriaen Block sails along Rhode Island coast.
1636—Roger Williams, banished from Massachusetts for religious and political dissension, establishes colony on Moshassuck R.; names it Providence.
1637—Colonists in alliance with friendly Indians defeat hostile Pequot Indians. Plantation Covenant for government of colony drawn up; important provision is freedom of conscience.
1638—Williams and associates form the Proprietors' Company for Providence Plantations; secure deed to lands from Narraganset chief Canonicus. William Coddington, John Clarke, and others leave Massachusetts to found second Rhode Island settlement, Pocasset (now Portsmouth), on Aquidneck Island, March 7. Anne Hutchinson settles in Pocasset; takes over political control of settlement from Coddington.
1639—Coddington, Clarke, and party found Newport. At Providence, Williams and followers form first Baptist church in America.
1640—Portsmouth and Newport unite under one government. First school in Rhode Island opens at Newport.
1643—Samuel Gorton moves to Shawomet which he had bought from Indians; renames it Warwick, 1647.
1644—Williams secures charter for Providence Plantations. Aquidneck called Rhode Island, March 13.
1646—First large ship built at Newport; begins major Rhode Island industry.
1647—Representatives from four towns of Providence, Portsmouth, Newport, and Warwick form first general assembly, May 19–21.
1651—Coddington gets own charter for Rhode Island; England annuls it in 1652 by reaffirming Williams' charter. Colonial Assembly prohibits slavery.
1654—Williams helps reunite four original towns.
1663—King Charles II grants colony a new charter.
1664—Block Island made part of Rhode Island, May 4.
1671—Joseph Jenk's blacksmith and carpenter shops open way for industrial development of colony.
1675—Great Swamp Fight in King Philip's War breaks power of Narraganset Indians; Providence burned; King Philip killed near Bristol.
1680—First wharf and warehouse built at Providence.
1686—Rhode Island included in Dominion of New England; governor Sir Edmund Andros demands it surrender its charter.
1689—Rhode Island resumes charter form of government, May 1. French privateers plunder Block Island in King William's War.
1693—First postal route to Boston established.
1694—Privateering of French vessels legalized by Colonial Assembly; becomes important enterprise of the colony.
1700—Colony enters three-way shipping trade in rum, sugar, and slaves.
1703—Connecticut and Rhode Island, after long controversy, agree to common boundaries, approved 1727–28, along present lines.
1726—James Franklin, brother of Benjamin Franklin, sets up first printing press in Rhode Island at Newport; prints 'Poor Robin's Almanac'.
1741—Massachusetts and Rhode Island agree on an eastern boundary; not settled until 1899; northern boundary settled, 1883; western border, 1887.
1755—Stephen Hopkins becomes governor of colony; in office until 1768, he leads opposition to British.
1764—Rhode Island College, renamed Brown University, 1804, founded at Providence
1769—Newporters scuttle British ship *Liberty.*
1772—Providence citizens burn British warship *Gaspee.*
1774—General Assembly prohibits importation of slaves.
1776—Rhode Island is first colony to declare its independence from England; General Assembly adopts name of State of Rhode Island; Nicholas Cooke, governor. First naval action of Revolution occurs off Jamestown; British bombard Bristol; seize Newport, Dec. 8, hold it till Oct. 25, 1779.
1778—Rhode Island adopts Articles of Confederation, February 9. British plunder Bristol and Warren; American forces fail to drive British from Newport, but prevent further invasion of state.
1784—State Emancipation Act frees slaves gradually.
1790—Rhode Island is 13th state to ratify U. S. Constitution, May 29. Samuel Slater begins textile industry in Pawtucket.
1791—First state bank chartered at Providence.
1794—Nehemiah Dodge begins manufacture of low-priced jewelry, now a major state industry.
1800—First state-wide free school law passed.
1810—First woolen mill in state built at Cranston.
1812—Use of steam power introduced in textile mills.
1813—Oliver Hazard Perry, born 1785 at S. Kingston, leads U. S. fleet in defeating British on Lake Erie.
1814—State sends delegates to Hartford Convention.
1816—First woolen power looms in U. S. installed at Peace Dale.
1817—First steamboat trip made on Narragansett Bay; regular service between Providence and New York City begins, 1822.
1823—Blackstone Canal chartered; completed, 1828.
1841—People's party under Thomas Dorr draws up constitution to replace colonial charter; existing government under Samuel King refuses to adopt it.
1842—Legal government adopts present state constitution; Dorr and King both claim governorship; Dorrites besiege Providence; Dorr convicted of treason and imprisoned, 1844; released later.
1845—Barnard School Law sets up state school system.
1846—George H. Corliss begins manufacture of steam engines at Providence.
1852—State abolishes capital punishment.
1854—Com. Matthew C. Perry, born 1794 at Newport, opens Japan to world trade.
1887—State agricultural school opened at Kingston; renamed Rhode Island State College, 1909.
1895—New poultry breed, Rhode Island Red, recognized.
1900—Amendment to state constitution provides that legislature shall meet in Providence (had met in Providence or Newport, 1854–1900). First legislative meeting in new capital, 1901.
1949—Assembly passes law banning racial and religious discrimination in employment.
1950—State grants Narraganset Indians right to vote.
1951—Legislature increases sales tax from 1% to 2%. Rhode Island Development Council established.
1952—Dennis J. Roberts Expressway, 9-million-dollar highway in Providence, dedicated.
1953—Meshanticut Interchange, to end traffic bottleneck in Cranston, completed at cost of 3 million dollars.


RHODE ISLAND
SCALE OF MILES
0 2 4 6 8 10
State Capitals
County Seats
Railroads
Copyright by C S HAMMOND & CO N Y
Longitude 71°30 West of Greenwich
71°50′
71°40′
71°20′
71°10′
41°50′
41°40′
41°30
41°20′
41°10′
PROVIDENCE
WASHINGTON
KENT
NEWPORT
MASSACHUSETTS
CONNECTICUT
BLOCK ISLAND SOUND
ATLANTIC OCEAN
Woonsocket
Pawtucket
Central Falls
East Providence
Cranston
Johnston
West Warwick
Warwick
East Greenwich
Bristol
Warren
Barrington
Newport
Jamestown
Portsmouth
Tiverton
Little Compton
Westerly
Hopkinton
Charlestown
Narragansett
Wakefield
Peace Dale
Wickford
Exeter
Scituate Res
Foster
Bridgeton
Pascoag
Slatersville
Manville
Lonsdale
Valley Falls
Saylesville
Esmond
Centerdale
Greenville
Lymansville
North Scituate
Thornton
Natick
Anthony
Coventry
Apponaug
Conimicut
Riverside
Fall River
Attleboro
North Attleboro
Mansfield
Taunton
North Dighton
Rehoboth
Somerset
Putnam
Danielson
North Grosvenordale
Stonington
Aquidneck I or Rhode Island
Conanicut Island
Prudence I
Block Island
Great Salt Pond
Sandy Pt
Southeast Pt
Black Rock Pt
Watch Hill
Point Judith
Sakonnet
Watuppa Pd

Baptist, Congregational, Methodist, and Lutheran. The Jewish faith is also represented.

Educational and Other Achievements

Nicholas Brown founded Rhode Island College (now Brown University) in Providence in 1764. He also worked to advance higher education for women. The state's public-school system began with the Barnard School Law in 1845. In that year Henry Barnard came from Connecticut to set up "one of the best systems of public instruction in the world," according to the educator Horace Mann. In 1919 Rhode Island passed a law which required all illiterate residents of the state between the ages of 16 and 21 to attend school until they learned to speak, read, and write English.

Among Rhode Island men who contributed to culture were Gilbert Stuart and Robert Feke, famous portrait painters. Outstanding silversmiths were Samuel Vernon and Jabez Gorham. The state was also the home of Jules Jordan, composer and conductor.

Nathanael Greene was Rhode Island's most brilliant Revolutionary War soldier and one of America's first great military leaders (*see* Greene). Commodore Oliver H. Perry was the "hero of Lake Erie," and his brother Matthew C. Perry opened Japan to world commerce. Esek Hopkins was the first commander of the American Navy. In 1804 Rhode Island College was re-named Brown University in honor of Nicholas Brown, merchant and philanthropist and son of the original founder. George Henry Corliss, inventor of a greatly improved steam engine, lived in Rhode Island.

Manufacturing and Other Industries

The rocky land surface of Rhode Island makes agriculture relatively unimportant. Farmers specialize in commodities which can be profitably produced on a small scale and easily shipped to nearby markets. The state is known for its development of Rhode Island Reds, a fine breed of chickens. Many large truck farms are located around Providence. The city is also an important Atlantic port (*see* Providence).

Rhode Island's minerals are few, mostly stone and sand and gravel. Its quarries produce granite for buildings. Other minerals are sandstone, quartzite, greenstone, and coal. Until about 1860, whaling was profitable. In Narragansett Bay fishing is still important. The catch includes such shellfish as lobsters, scallops, mussels, clams, oysters, and crabs.

RHODE ISLAND

COUNTIES

Bristol	29,079	E 3
Kent	77,763	C 4
Newport	61,539	E 4
Providence	574,973	C 2
Washington	48,542	C 5

CITIES AND TOWNS

Adamsville	250	F 4
Albion	800	D 2
Allenton	250	D 4
Alton	300	B 5
Anthony	2,000	C 3
Apponaug		D 3
Arcadia	100	B 4
Arctic	3,000	C 3
Arkwright		C 3
Arnold Mills	300	D 2
Ashaway	1,022	B 5
Ashton	1,000	D 2
Auburn		D 3
Barrington	†8,246	E 3
Berkeley	1,400	D 2
Block Island	848	C 6
Bradford	1,024	B 5
Bridgeton	661	B 2
Bristol	†12,320	E 4
Bristol Ferry	130	E 4
Bristol Highlands	200	E 3
Buttonwoods		D 3
Canonchet	150	B 5
Carolina	200	B 5
Centerdale	2,500	D 2
Centerville	2,000	D 3
Central Falls	23,550	D 2
Charlestown	†1,598	C 5
Charlestown Beach	300	C 5
Chepachet	1,200	C 2
Clayville	300	B 3
Coggeshall	30	E 3
Conanicut Park	45	D 4
Conimicut		D 3
Coventry (Washington)	2,800	C 3
Coventry Ctr.	†9,869	C 3
Cowesett	400	D 3
Cranston	55,060	D 3
Crompton	1,500	C 3
Cumberland Hill	1,200	D 2
Davisville	1,400	D 4
E. Greenwich	†4,923	D 4
E. Providence	†35,871	D 3
Edgewood		D 3
Elmwood	27,000	D 3
Escoheag	60	B 4
Esmond	2,000	C 2
Exeter	†1,870	C 4
Fiskeville		C 3
Forestdale	550	C 1
Foster	†1,630	B 2
Foster Ctr.	225	B 3
Galilee		C 5
Georgiaville	1,247	C 2
Glendale	243	C 2
Gould	200	C 5
Graniteville	1,000	C 2
Greene	71	B 3
Greenville	2,000	C 2
Greenwood		D 3
Greystone	1,500	D 2
Hamilton	950	D 4
Harmony	500	C 2
Harris	1,000	C 3
Harrisville	1,055	B 2
Hillsgrove	880	D 3
Hope	800	C 3
Hope Valley	1,000	B 4
Hopkinton	†3,676	B 5
Howard	6,000	D 3
Hoxsie		D 3
Hughesdale	500	C 3
Island Park		E 4
Jamestown	†2,068	D 5
Jerusalem		C 5
Johnston	†12,725	D 3
Kenyon	100	C 5
Kingston	2,156	C 5
Knightsville		D 3
LaFayette	550	C 4
Lakewood	1,200	D 3
Liberty		C 4
Lincoln Park	450	D 3
Lippitt	500	C 3
Little Compton	†1,556	E 4
Longmeadow		D 3
Lonsdale	2,500	D 2
Lymansville		C 2
Manton	2,500	D 3
Manville	3,429	D 2
Mapleville	1,015	B 2
Marieville		D 2
Matunuck	300	C 5
Mellville		E 4
Middletown	†7,382	E 4
Misquamicut	30	B 6
MoosupValley	310	B 3
Narragansett	†2,288	D 5
Nasonville	677	C 2
Natick	2,000	C 3
Nausauket	400	E 3
Newport	37,564	D 5
Nooseneck	150	C 4
North Scituate	1,000	C 3
North Tiverton	4,000	E 4
Norwood	2,300	D 3
Oak Lawn	600	C 3
Oakland	557	C 2
Oakland Beach	10,000	D 3
Olneyville		D 3
Pascoag	1,760	B 2
Pawtucket	81,436	D 2
Pawtuxet	1,850	D 3
Peace Dale	2,177	D 5
Perryville	200	C 5
Phenix	1,500	C 3
Phillipsdale	1,500	D 2
Pinehill	50	C 4
Point Judith		D 5
Pontiac	1,300	D 3
Portsmouth	†6,578	E 4
Potter Hill	400	B 5
Primrose	350	C 2
PROVIDENCE	248,674	D 2
Prudence		D 4
Prudence Isl.	80	E 4
Quidnick	1,500	C 3
Quonochontaug	300	B 6
Quonset Pt.	700	D 4
Rice City	145	B 3
River Point	1,000	D 3
Riverside	10,000	D 3
Rockville	175	B 4
Rumford	10,000	D 2
Sakonnet	50	E 5
Saunderstown	450	D 4
Saylesville	3,500	D 2
Shannock	300	C 5
Shawomet	1,500	D 3
Simmonsville	500	C 3
Slatersville	1,780	C 1
Slocum	100	C 4
Smithfield	†6,690	C 2
Snug Harbor	500	C 5
S. Foster	70	B 3
S. Portsmouth	4,500	E 4
Stillwater		C 2
Summit	110	B 3
Tarkiln	191	C 2
The Hummocks		E 4
Thornton		D 3
Tiverton	†5,659	E 4
Tiverton Four Corners	12	F 4
Union Village	1,200	C 2
Usquepaug	142	C 4
Valley Falls	2,500	D 2
Wakefield	3,047	D 5
Wallum Lake	167	B 2
Warren	†8,513	E 3
Warwick	43,028	D 3
Warwick Neck		D 3
Washington (Coventry)	2,800	C 3
Watch Hill	750	B 6
Weekapaug	200	B 5
W. Barrington	4,250	E 3
W. Glocester	100	B 2
W. Greenwich Center	18	B 4
W. Kingston	500	C 5
W. Warwick	†19,096	C 3
Westerly	†12,380	B 5
White Rock	375	B 5
Wickford	2,437	D 4
Wickford Jct.		C 4
Wood River Jct.	103	B 5
Woodville	37	B 5
Woonsocket	50,211	D 1
Wyoming	315	B 4

†Population of township

Since 1790, when Samuel Slater started his cotton mill at Pawtucket, Rhode Island has been a leading manufacturing state. Almost half the workers in the state are employed in one of its 2,500 manufacturing establishments. The most important state industry is the manufacture of textiles. The production of woolens and worsted accounts for almost half of the total value of this industry. Cotton and rayon fabrics are still manufactured in large quantities, although much of this industry has moved to the South. Other important state manufactures are jewelry, silverware, and machine tools. The state is also noted for its fine cutlery and hardware.

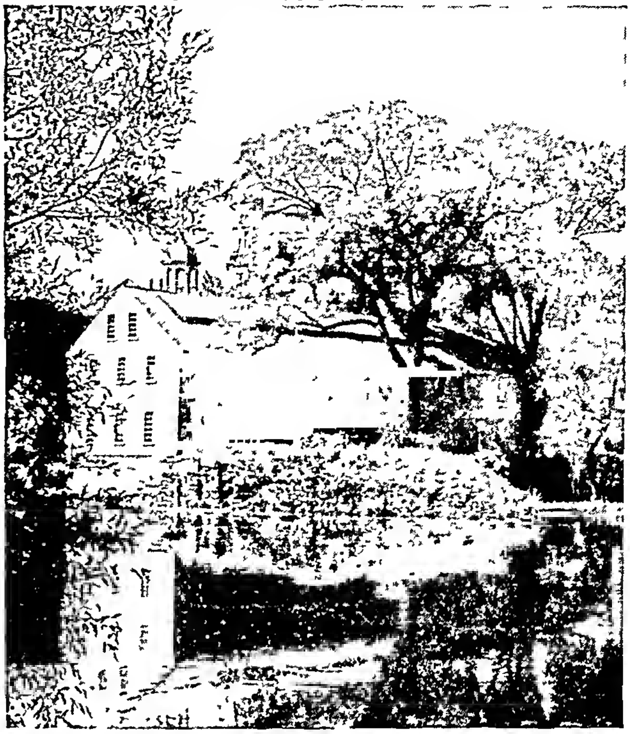
Government within the State

In 1935 Rhode Island reorganized and simplified its state government. It then reduced 80 state boards and agencies to 11 departments.

In local government the state is distinctive. The seven cities in the state have a mayor and council form of government. All other communities are governed entirely by town meeting.

At least once a year, citizens gather in town meeting to talk over and to vote upon local issues and officers. They also elect a small group of selectmen whose duty it is to "order and manage the prudential affairs of the town."

EARLY AMERICAN COTTON MILL



Samuel Slater, who established the use of spinning machines in the United States, built this cotton mill in Pawtucket. Its cupola bell summoned workers to their jobs.

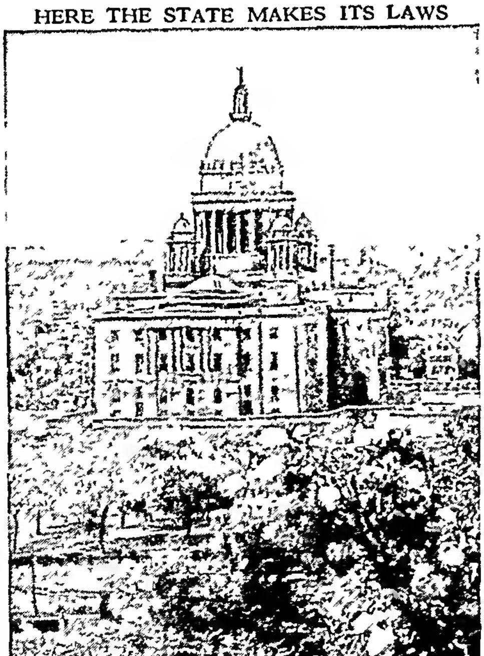
History of the State

The first colony in what became Rhode Island was founded by Roger Williams at Providence in 1636. This and later settlements in the 1600's were founded by religious leaders who dissented from the established church in Massachusetts. Sometimes the dissenters quarreled among themselves, and the loser left to found another settlement in the Rhode Island area.

In 1644 the English Parliament granted a charter which incorporated these settlements into the Providence Plantations. The charter set forth the principle of freedom of religious beliefs. This principle was reaffirmed in a royal charter which was granted in 1663.

In 1724 the assembly limited the right to vote to men who owned £100 worth of property or more and to their eldest sons. By 1840 under this law, half the men in Rhode Island were denied the suffrage. In 1841 Thomas Wilson Dorr led a rebellion against this restriction. As a result, a new constitution was drawn up, with the provision that all men had the right to vote, but it never went into effect. Meanwhile Dorr was convicted of treason and sentenced to life imprisonment but was soon released. Finally, in 1888, the state removed all property restrictions and gave the vote to all male citizens over 21. Women gained the suffrage in 1919.

HERE THE STATE MAKES ITS LAWS



The State Capitol building in Providence is noted for its architectural simplicity and strength. It is built of marble and white granite. Its State Chamber has a portrait of George Washington by the famous painter Gilbert Stuart.

Rhode Island was one of the first colonies to rebel against the British. In 1772 citizens of Providence burned the British cutter *Gaspee*, which had been enforcing revenue laws. The British occupied Newport in 1776-79. A battle in Portsmouth in 1778 prevented their advance. In 1780-81 America's French allies made Newport their headquarters. (*See also* chronology in Rhode Island Fact Summary; United States, section "New England.")

RHODES, CECIL JOHN (1853–1902). South Africa has long attracted men eager to win wealth or political power. In the 1880's and 1890's Cecil Rhodes won both. He became very rich in gold and diamonds, and as prime minister of Cape Colony he was virtually dictator of all South Africa. Rhodes' ambition was not for himself, but for his native Britain. He brought into the British Empire Northern and Southern Rhodesia, twin lands that extend over nearly 450,000 square miles. He never married, and he left his fortune to establish scholarships to Oxford University.

Cecil Rhodes was born July 5, 1853, at Bishop's Stortford, England. When he was 17, tuberculosis canceled his plan to enter Oxford University. He joined a brother already in South Africa just in time to take part in the rush to the newly discovered Kimberley diamond fields. Within a few months he had dug up a fortune in diamonds.

The vigorous outdoor life restored his health, and he was able to resume his plan for a college education. For eight years he alternated between study at Oxford and work in South Africa. In 1881, just before taking his degree, he was elected to the parliament of Cape Colony. In 1890 he became its prime minister.


CECIL RHODES
Rhodes won vast lands for the British in South Africa.

In addition to his political power Rhodes gained control of the huge companies that owned most of the gold and diamond fields. He was managing director of one of them, the British South Africa Company. In 1893 he was victorious over the Matabele natives and their king, Lobengula. Meantime he schemed against his strongest political opponent, Paul Kruger. Kruger was leader of the Dutch settlers, the Boers, and president of the independent Transvaal Republic. In 1895 Dr. L. S. Jameson, Rhodes's friend, raided the Transvaal, hoping to overthrow the Boer government. The raid failed, and Rhodes was proved to have aided Jameson. He was forced to resign his posts as prime minister and as director of the British South Africa Company.

Rhodes moved north to Rhodesia, planning to develop its natural resources. A few months later he showed he was still a master statesman. The natives had revolted and could not be suppressed. They had been driven back to their stronghold in the Matoppo hills, but they were armed and dangerous. Rhodes and three companions camped at the foot of the hills, unarmed. They waited patiently until the chiefs were ready for parley. Finally a conference was arranged in the hills. Rhodes heard their grievances, promised relief, and the rebellion was over.

In 1898 Rhodes was again elected to the Cape Colony parliament and was on his way to regaining his old power when the Boer War (1899–1902) began. He took part in the defense of Kimberley, but his health, always complicated by the effects of his boyhood illness, finally broke. He died March 26, 1902, and was buried in a tomb hewed in the granite of the Matoppo hills. (*See also* South Africa, Union of.)

The Rhodes Scholarships

Cecil Rhodes left his money to establish about 175 scholarships at Oxford University. These were to be held for two or three years by selected students from various parts of the British Empire and from the United States. Fifteen scholarships were also allotted to Germany. The scholarships were originally fixed at £300 a year but have been raised to £500.

In the United States 32 scholarships are offered each year. Four go to each of eight districts. Candidates must be male citizens of the United States, between 19 and 25 years of age, and must have completed at least the sophomore year at a recognized college or university. They may apply from their home state or from any state in which they have received at least two years of their college education. Each college or university may appoint one to five candidates. From these the state committees of selection nominate two candidates each. District committees make the final selection on the basis of: qualities of manhood, force of character, and leadership; literary and scholastic ability and attainments; physical vigor, as shown by interest in outdoor sports or in other ways.

Scholarship winners may select any course of study at Oxford that they are qualified to pursue. If they desire they may spend the third year of the scholarship in postgraduate study at some other university.

RHODES. Twelve miles off the Turkish coast in the Aegean Sea stands the mountainous island of Rhodes. This Greek possession is the largest and the farthest east of the Dodecanese Island group. The principal city, on the northeast tip of the island, is also called Rhodes.

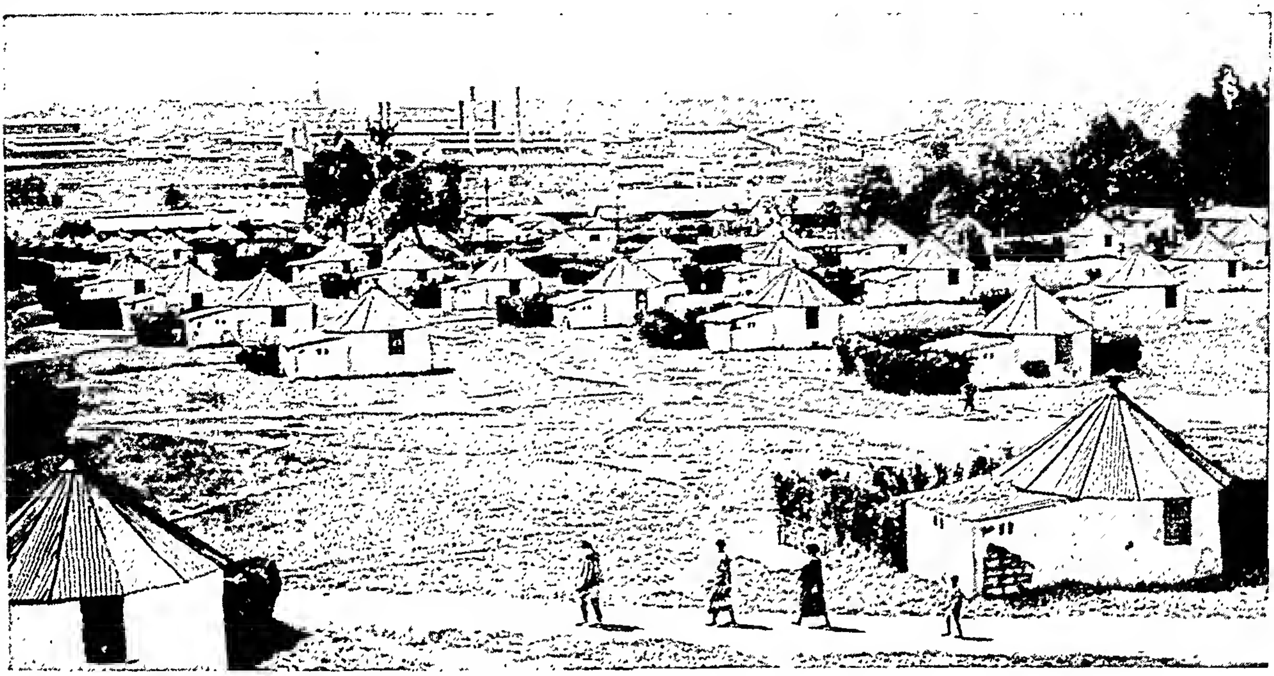
About one third of the island's 542 square miles of land, mainly along the coast, is *farmed*. Agricultural products include barley, tobacco, cotton, figs, and olives. Rainfall is plentiful, and the hills are well-forested.

Since earliest times the island has been a key to the Near East. It was first colonized by the Dorian Greeks about 1000 B.C. The city was founded 407 B.C. It grew rapidly and soon became a more important trade center than its rival, Athens, on the Greek mainland. One of its attractions in ancient times was the famed Colossus of Rhodes, one of the "seven wonders" of the ancient world (*see* Seven Wonders of the World).

Later Rhodes became a possession of the Roman Empire of the West. Still later it fell under the control of Byzantium. During the Crusades Rhodes was seized by a crusading order called the Knights Hospitalers (*see* Crusading Orders). They rebuilt and fortified the city of Rhodes. The knights lost the island to the Ottoman Turks in 1522.

Italy took the island in 1911–12 and made it a military base. During World War II it was heavily bombed by the Allies. After the war, the peace treaty ceded Rhodes to Greece.

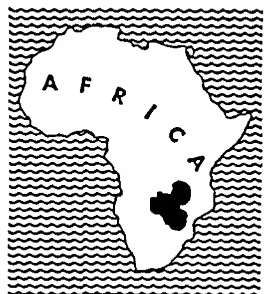
Early geographers did not include Rhodes in the Dodecanese group (Dodecanese in Greek means "12 islands"). Italy, however, officially designated a new group, raising the number to 14 and including Rhodes. Population (1951 census), 65,206.



The Roan Antelope copper mine is one of the largest in Rhodesia. In the foreground are the pointed-roofed houses of the African miners and their families. In the background is the smelter. Copper is Rhodesia's largest single product.

In an underground level of the mine a white foreman supervises African miners. They are operating a rock breaker.

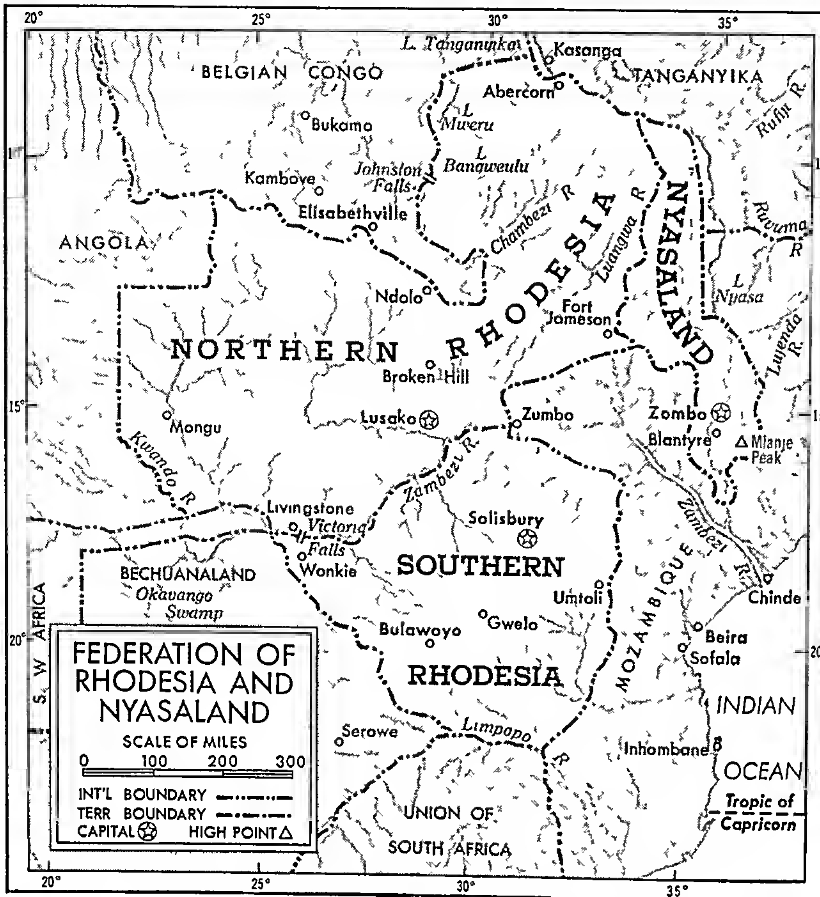
RHODESIA—
Land of Copper



RHODESIA AND NYASALAND, FEDERATION OF. Created in 1953 by an act of Britain's Parliament, the Federation of Rhodesia and Nyasaland includes the protectorate of Northern Rhodesia, the self-governing colony of Southern Rhodesia, and the protectorate of Nyasaland. The main function of the federal government is to co-ordinate and expand the economic life of the Federation. The federal government also handles the most important foreign matters through the Foreign Office in London. A governor general represents Queen Elizabeth II. There are a prime minister and an elected assembly. The provisional capital is at Salisbury in Southern Rhodesia. The two Rhodesias and Nyasaland maintain their own governments within the Federation.

The Land and the People

The Federation is on the rolling grasslands of the south-central African plateau. It is bordered on the north and west by Tanganyika, the Belgian Congo, Angola, and Bechuanaland; on the south, by the Union of South Africa; and on the east, by Mozambique and Lake Nyasa. Most of the land is more than 4,000 feet above sea level. The days are warm; the nights, cool.



Britain's Federation of Rhodesia and Nyasaland has three political divisions: the protectorates of Northern Rhodesia and Nyasaland and the self-governing colony of Southern Rhodesia.

The world's greatest waterfall, Victoria Falls, is in the Zambezi River, which divides Northern and Southern Rhodesia (*see* Victoria Falls).

The African tribes of the Federation are almost all Bantu Negroes. Their tribal organization is still fairly intact. Most tribes have a paramount chief who is advised by a native council. In turn, the chief is responsible to the British governor.

Cattle raising is most important in areas not infested by the deadly tsetse fly. The tribes also raise maize (corn) and millet. The thatched huts of their villages (kraals) are built around an enclosure where the cattle are kept at night.

There are fewer white people in the Federation than in either East or South Africa. Salisbury, Bulawayo, Lusaka, and the other cities are small but cosmopolitan. Besides the British, there are American and Canadian families who help administer the vast mining industries. They usually stay under contract for several years and then go home or on to a new assignment. The mining companies provide houses and schools for the children. A mine usually has its own hospital and a club with a swimming pool.

Mining and Agriculture

The Federation is the third largest copper-producing region in the world. Most of the metal comes from the copper belt which Northern Rhodesia shares with the Belgian Congo. The next most important products are tobacco, from Southern Rhodesia, and cotton, from Nyasaland. Other minerals mined include lead, zinc, cobalt, gold, tin, iron, and tungsten.

The railroads of the Federation connect with the systems of both the Union of South Africa and the Belgian Congo. They find an outlet to the sea at the Mozambique ports of Beira and Lourenço Marques (*see* Mozambique). The principal cities are linked by both hard- and gravel-surfaced roads. There are international airports at Salisbury, Bulawayo, and Livingstone.

History

The ruins of ancient stone cities in Southern Rhodesia are a mystery even today. Nobody knows who built them. The largest ruined city is called Zimbabwe, and the remains indicate that the people who once lived there were engaged chiefly in mining and smelting copper and gold.

Arabs explored this region in the Middle Ages. The first Europeans to arrive were Portuguese sailors in the 1400's (*see* Africa). The region came under British influence in the 1880's. It was then called Zambezia after the great river flowing through its center. Pioneers from South Africa built a fort on the site of the present city of Salisbury.

Then came Cecil Rhodes, for whom the land was later named. He defeated a Matabele chief named Lobengula and proclaimed all Rhodesia as part of the British Empire. (*See also* Rhodes, Cecil John.)

In 1895 Zambezia was officially divided into Northern Rhodesia and Southern Rhodesia. In 1923 Southern Rhodesia became a self-governing colony within the British Commonwealth. The Federation of Rhodesia and Nyasaland was formed in 1953 with a view to eventual dominion status.

The total area of the Federation is about 480,000 square miles (Northern Rhodesia, 287,950; Southern Rhodesia, 150,000; Nyasaland, 37,600). The total population is 6,393,531 (Northern Rhodesia, 2,114,518; Southern Rhodesia, 2,101,000; Nyasaland, 2,178,013). (For Reference-Outline and Bibliography, *see* Africa.)

RHODODEN'DRON. Throughout June and July the colorful flowers and shining foliage of the rhododendron beautify the mountain slopes of North America. The flowers are pink, rose, lilac, or purple.

Direct-color photograph *Fernand Bourges, by courtesy of Life Magazine*

A RHODODENDRON MADE OF GLASS

This beautiful rhododendron is one of more than 700 life-size glass flowers and plants in the Botanical Museum in the University Museum of Harvard Leopold Blaschka and his son Rudolph, of Dresden, Germany, worked 50 years to create this famous collection. No one has ever worked more skillfully in blown glass.

The species usually found in the East is the American, or great, rhododendron. The Carolina, or Catawba, rhododendron grows in the high Appalachians. A species called coast rhododendron is found on the Pacific coast (for picture in color, *see* Flowers). Other species flourish in Europe and Asia, especially in the Himalayas, Borneo, and Java. Some treelike species are 40 to 60 feet high. Shrub forms may reach a height of 20 feet. Most species of rhododendron are evergreen.

Rhododendrons are cultivated widely as garden shrubs. Many hybrid or grafted rhododendrons develop more beautiful flowers than do native species. The plants flourish in moist but well-drained peaty soil. Rhododendrons belong to the heath family and are akin to the azaleas. Because they contain a resinoid called andromedotoxin they are poisonous.

The flowers of the great rhododendron, often called the rosebay rhododendron, grow in clusters from a conelike bud. They vary in color from rose-pink to white except at the throat, where they are greenish, spotted with yellow and orange. The dark-green leaves are lance-shaped and evergreen, drooping in winter. The scientific name of the great rhododendron is *Rhododendron maximum;* of the Catawba species, *Rhododendron catawba;* and of the coast rhododendron, *Rhododendron macrophyllum.*

RHONE RIVER. One of Europe's most picturesque and historic streams is the Rhone River. It flows from the Swiss Alps west and south to the Mediterranean Sea, draining the eastern quarter of France.

Since prehistoric times the valleys of the lower Rhone and its principal tributary, the Saône, have provided routes for the movements of people and goods between the Mediterranean Sea and northern Europe. The Rhone itself has parts too swift, too narrow, or too shallow to be navigable. It cannot compare with other leading European rivers as a waterway, although its course has been provided with locks, dams, and canals.

The Rhone originates in the Alps of southern Switzerland. It springs as a torrent from the foot of a great glacier nearly 6,000 feet above sea level. Swollen by many mountain streams, it descends through wild gorges and flows southwest through a broad valley lying between the Bernese Alps to the north and the towering Pennines to the south. Here picturesque old villages and thriving small towns cluster along its banks. Great St. Bernard and the Matterhorn can be seen in the distance. At Martigny, 75 miles from its source, the river turns abruptly to the northwest, flows through a marshy plain, and pours into Lake Geneva. There it leaves the impurities gathered in its turbulent course through the mountains; it emerges from the southwestern end of the lake limpid and clear. A mile from Lake Geneva the Arve joins the Rhone, emptying into it silt from the glaciers of the Mont Blanc Range.

As the Rhone enters France it flows swiftly through narrow gorges around the southern spur of the Jura Mountains. Near Géuissiat its power has been harnessed in Europe's second largest hydroelectric project. The Ain flows into the Rhone from the north after the latter turns west toward Lyons.

The huge, unruly river receives the Saône, its principal tributary, just below Lyons. Broadened and doubled in volume it now turns and flows directly southward. Between Lyons and the Mediterranean Sea, a distance of 230 miles, the steep slopes above the river are covered with rich vineyards. Along the east bank lie such historic cities as Vienne, Valence, Avignon, Tarascon, and Arles. The Isère, the Drome, and the Durance rivers, bringing down melted snow from the lofty Dauphiné Alps, join the Rhone from the east. On the west the Ardèche River is the only important tributary of the Rhone. About 25 miles from the Mediterranean Sea the Rhone divides into two main branches—the Grand Rhone, running southeast, and the Petit Rhone, going southwest—and thus discharges its waters into the sea. Its total length is a little more than 500 miles, including the 45-mile length of Lake Geneva.

The headwaters of the Saône might well be considered the headwaters of the Rhone. The Saône rises in the Vosges Mountains in northeastern France and flows 301 miles southward before meeting the Rhone. Its course is much more direct than that of the upper part of the Rhone.

Canals connect the Saône with the Marne, the Yonne, the Loire, the Rhine, and the Moselle rivers. The Rhone-Marseilles Canal, leading from the Rhone at Arles to the seaport Marseilles, is one of the chief outlets for the river commerce of France. At Rove, this canal flows underneath the Nerthe Hills through the huge Rove Tunnel, which is 72 feet wide, 50 feet high, and nearly 4½ miles long.

RHUBARB. The long, juicy leaf stalks of the rhubarb, or "pieplant," are among the earliest contributions of the garden in spring. These stalks, which have an acid, fruitlike taste, make delicious pies and sauce.

When a few rhubarb roots have been set out in the garden, practically no more attention need be given the bed. It will renew itself year after year and the stalks are simply pulled from the low crown of the plant as needed. Rhubarb requires a rich soil, however, and gardeners can force early growth by putting fertilizer around the roots in the spring. Placing an old bushel basket, half barrel, or other cover over the plants causes the leaves to shoot up rapidly in search of light and thus produces longer stems that are especially succulent and tender.

Rhubarb, a member of the dock family, has large heart-shaped leaves sometimes a foot wide. Cultivation has greatly improved the plant, making the stems less woody, with thinner skin and better flavor than the stems of the wild plant. In spring the skin is flushed with red, which adds attractive coloring to the light green sauce. The scientific name of rhubarb is *Rheum rhaponticum.* The roots of certain species are sometimes employed in medicine for their cathartic and tonic properties.

RICE—STAFF *of* LIFE *in the* ORIENT

RICE. The principal food of at least one-half the people in the world is rice. In the crowded countries of the Far East, where over a thousand million people live, this grain is more important than bread and potatoes are in North America. In normal times the people of southern and eastern Asia eat between 300 and 400 pounds of rice apiece each year—approximately a pound a day. Some people live almost entirely on boiled rice. The more fortunate have a few vegetables, a little meat and fish, and local fruits in season, as well as rice. Rich people may have considerably more variety, but even they eat rice as a staple food.

As rice dominates the diet in much of the Orient, so it dominates the daily lives of millions of farm families. The farmers of Asia raise more than 145 million tons of rice a year. They raise most of it in small fields with little or no help from power-driven machinery. Rice farmers and their families spend most of their waking hours in the fields planting, irrigating, cultivating, and harvesting their crop.

Unless farmers are careful, their rice fields may provide a feast for hungry birds. The boys shown here are sitting on a raised platform in a rice field in Java, Indonesia. All day long they jerk their ropes to frighten birds away from the ripening grain.

How Rice Is Raised

Rice is a cereal grass (*Oryza sativa*) which needs a great deal of water and a long, warm growing season. Most varieties require four to six months from planting to harvesting. Rice grows better than any other grain in the tropical and semitropical parts of Asia. It also thrives in temperate regions where the growing season is suitable and water is plentiful. The yield per acre is highest in rice-producing regions farthest from the equator, because the days are longer during the growing season and the rice therefore gets more sun.

There are two types of rice: upland and lowland rice. These names have nothing to do with altitude. Upland rice, also called dry rice, is grown without irrigation where rainfall is plentiful. Lowland, or wet, rice is raised in fields flooded with two to eight inches of water. Upland rice tends to grow in patches, to have a lower yield per acre, and to be of poorer quality. Most of the world's supply of rice is lowland rice.

The typical Oriental rice farmer sows his grain by hand in a muddy field and then floods the field. After three or four weeks he transplants the seedlings, setting them out in even rows in a plowed and flooded field. This field, where the rice will grow to maturity, is called the paddy field. It has to be weeded regularly. The farmer may or may not drain the field for weeding.

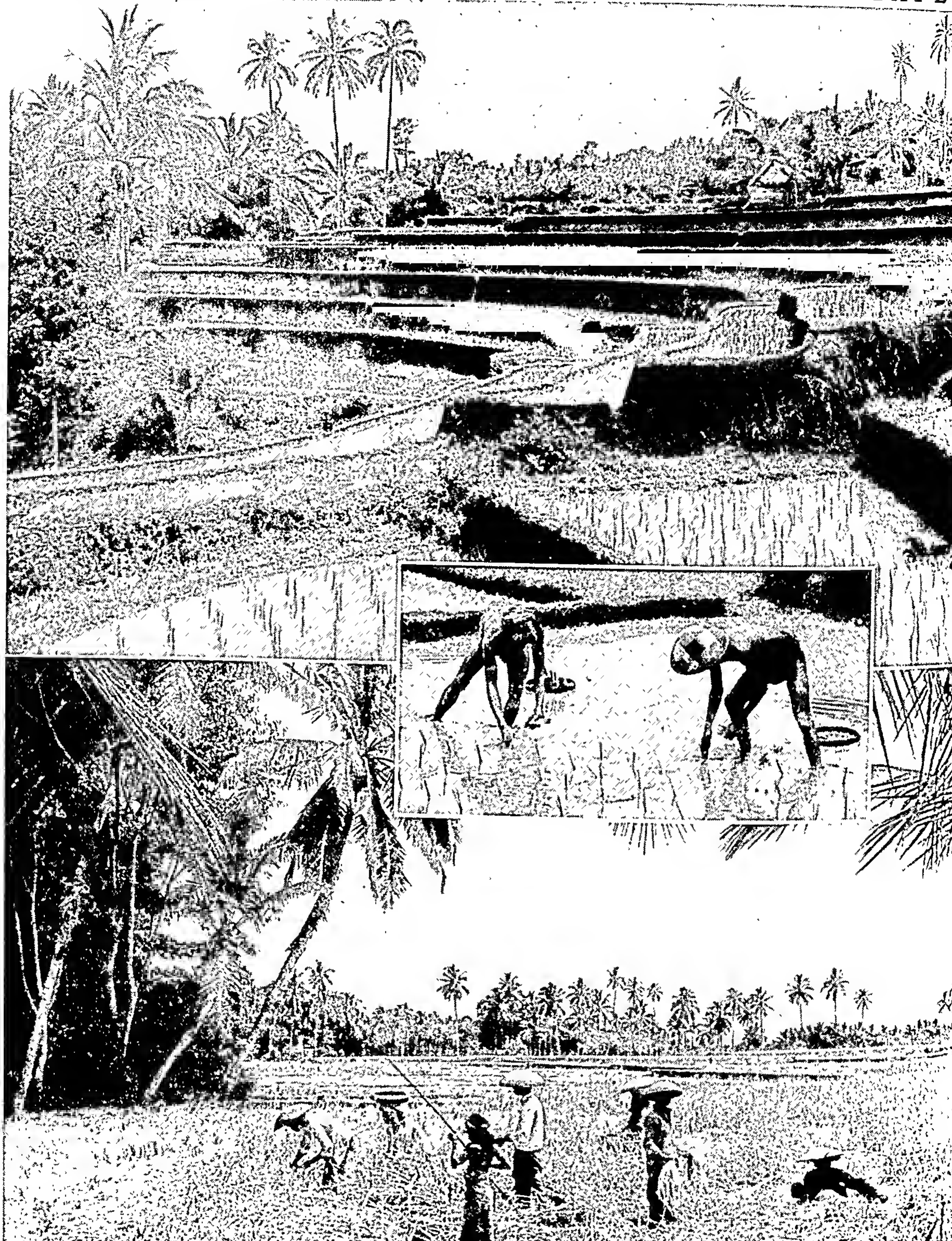
Getting water into the rice fields is a laborious process. As a rule an irrigation ditch or canal connects a series of fields with a river or stream. Water is pumped from the ditch into the fields. A dike, or low wall of earth, surrounds each field to hold in the water. The pump may be nothing but a wooden wheel with cups or paddles attached, which the farmer operates like a treadmill. A few rural sections have motor-driven pumps for community use. (*See* China, section "Farming Methods and Products.")

When the leaves of rice begin to turn from green to yellow, the farmer drains the field. The grain then ripens rapidly in the sun. The farmer and his family harvest their crop with sickles, cutting the plants close to the ground. A common way of threshing is to beat the heads of grain against the inside walls of a barrel or box. Another method is to pull the stalks through a saw-toothed frame placed over a box. Milling of rice for home use may consist simply of hulling in a hand-operated wooden mill. Most of the rice the farmers sell is shipped in bags to mills where machinery does the hulling.

Rice Production Around the World

Asia raises about 95 per cent of the world's rice. China is the leading producer. Next come the Indian peninsula, Japan, Indonesia, Siam (Thailand), Indo-China, and Burma. Only Burma, Indo-China, and Siam normally raise enough to provide a surplus for export. In spite of big production the other Asiatic countries need to import large quantities of rice.

GROWING RICE—THE ORIENT'S FOOD STAPLE



Most of the world's rice is produced in southeastern Asia by the hand-planting and harvesting methods illustrated here. Where rice is grown on hillsides the ground is carved out into "staircase" terraces (top picture) with rims of sod to hold the water on the "paddy fields" and keep the soil from being washed away. Three or four weeks after the seeds are planted, the young sprouts are replanted (inset picture) in carefully spaced rows. When the leaves of the plants begin to turn yellow, the water is drained from the field. When the grain is harvested (bottom picture) the stalks are cut close to the ground.

Rice is grown in every country of the Western Hemisphere except Canada. The United States and Brazil are the leading producers and exporters. Ecuador and British Guiana export some rice. The leading users of rice, in consumption per person, are Surinam, the Hawaiian Islands, Cuba, and Puerto Rico. All four raise rice, and all except Surinam import rice from the continental United States. Rice is a staple food in Mexico and the countries of Central and South America, though it is less important than corn, beans, or wheat. Most of these countries raise enough rice for their own needs.

Rice has been grown in the United States since colonial days, but large-scale production did not develop until the 20th century. The amount used varies from less than a pound a year per person in many Northern states to about 100 pounds a year per person in parts of Louisiana. Louisiana, Texas, Arkansas, and California lead in production.

Europeans eat rice occasionally, but rice is not the main, basic food in any part of Europe. The leading European producers of rice are Italy, Spain. Portugal, and Bulgaria. In Africa rice thrives along the Nile River in Egypt, where the soil is rich and the fields are easily flooded. Egypt is one of the leading exporters of rice.

Modern farm machines are now made for plowing, sowing, watering, harvesting, and threshing. They can be used in rice production where the fields are large and the water supply can be controlled to permit the free movement of large, heavy machines. Machine methods have been especially successful in the United States, the state of Rio Grande do Sul in Brazil, and the Sonora Valley of Mexico. Rice growers in Europe and Egypt tend to use a combination of hand and machine methods.

Food Value of Rice

Crude milling produces "brown rice"—rice with the germ and outer bran skin intact. Such rice is about 7.5 per cent protein, 1.8 per cent fat, and 76.7 per cent carbohydrate. It is rich in thiamine (vitamin B_1) and minerals. Machine milling which produces white, polished rice removes the bran and part of the germ, thus removing about 75 per cent of the thiamine, most of the minerals, and part of the fat. Parboiling or vacuum treatment before milling helps preserve food values, or vitamins may be added.

Wild rice, which grows in Canada and the northern part of the United States, is an entirely different plant (*Zizania aquatica*). It was a favorite food of the Woodland Indians and is marketed on a small scale today in the United States.

RICHARD, *Kings of* ENGLAND

RICHARD I (1157–1199). Richard I, called the Lion-Hearted (Coeur de Lion) came to the throne in 1189. He was more than six feet in height and fair-haired and blue-eyed. As his nickname shows, he was a splendid fighter. He was a poet also, and men loved to hear him sing; but as a king he was too careless of his duties to be called a great ruler.

Richard grew up wholly under French rather than English influences. Both his parents, the energetic Henry II and the forceful and passionate Eleanor of Aquitaine, were of French birth and education. His father was the first Plantagenet king of England, but his possessions in France were greater than all England. French was the language of the Plantagenet court, where gay troubadours and minstrels were always welcome. French was Richard's native tongue, and almost all his life was spent in France. Even after he became king he made only two brief visits to England.

At the age of 15 Richard was formally placed in charge of his mother's duchy of Aquitaine, in southern France. Next year he joined his brothers, aided by the French king, in a widespread but unsuccessful revolt against their father (1173). He also engaged in struggles with his elder brother Henry and his younger brother John. The death of his brother Henry (1183) made Richard the next heir to the throne, to which he succeeded on the death of his father in 1189.

News of the recapture of Jerusalem by the Mohammedans, two years before, had stirred all Europe, and great preparations were being made for the Third Crusade. For Richard this proved the great undertaking of his life. He made a brief visit to England to be crowned and to collect money to finance his share in the crusade. While there he made Hubert Walter chief officer of the crown. Hubert Walter governed better than Richard would have done, and saved the throne for Richard when John plotted to seize it during his brother's absence.

Richard returned to the continent to complete his preparations. The English fleet sailed by way of Gibraltar to Marseilles, while Richard journeyed overland to the same port. He joined King Philip of France at Sicily, where they wintered and quarreled violently. Richard again turned aside on the way to the Holy Land, this time to fight with the ruler of Cyprus. He finally joined Philip at the siege of Acre, which surrendered in July 1191.

Because of his military skill and courage, Richard was soon acknowledged as chief leader of the crusade. King Philip shortly returned to France, to plot against his rival. For more than a year Richard remained in Palestine. When he fell ill of fever it is said that his great opponent, Saladin, the chivalrous leader of the Mohammedans, sent him fruit and snow. "He was brave," says an Arab writer, "experienced in war, and fearless of death. If he had been alone among millions of enemies, he would not have declined battle; when he attacked there was no resisting." Twice the crusaders were within two days' march of Jerusalem but were unable to take that holy city. At last Richard negotiated a truce for three years, under which the Christians might safely visit the Holy Sepulcher. He then sailed for home, in October 1192.

RICHARD I DEPARTS FOR THE HOLY LAND

Richard I, called the Lion-Hearted, was bold and reckless and loved adventure. Here we see him boarding a ship for Palestine to try to win back the Holy Land to Christian rule. Under his white tunic he wears, like his knights, a suit of flexible chain mail. The painting, by Glyn Philpot, hangs in the Houses of Parliament, London.

While on the Crusade, Richard had not only quarreled with Philip but had grossly insulted Leopold, duke of Austria. He had intended to sail to Marseilles; but he learned of a plot to seize him as soon as he reached the coast of France, so he landed instead at the head of the Adriatic Sea and then traveled overland in disguise. He was betrayed when he reached Vienna and captured by Leopold (December 1192). Leopold turned him over to Henry VI, the Holy Roman emperor, who demanded a huge sum for his release.

Meanwhile Richard's brother John, in England, had been plotting with Philip to divide Richard's realm. John wanted the emperor to keep Richard a prisoner, but Hubert Walter raised the money for his ransom and he was set free early in 1194.

Richard hastened to England but stayed only long enough to raise more money for a new campaign in France. He spent the remaining five years of his life fighting against Philip and building, with great engineering skill, his "Saucy Castle," the Château Gaillard, in Normandy. While besieging a castle in southern France he was hit by a crossbow bolt and died a few days later. His brother John succeeded him.

Even in Richard's lifetime his adventures were the subject of song and story. An early French chronicle tells how Richard's faithful minstrel, Blondel, searched for his king, while he was a prisoner, by singing under the windows of many castles until he heard Richard reply. Richard was an important figure in Sir Walter Scott's novels 'Ivanhoe' and 'The Talisman'. A truer picture of him is given by Maurice Hewlett in his novel 'The Life and Death of Richard Yea-and-Nay'.

RICHARD II (1367–1400). Richard II ruled from 1377 to 1399. His father was Edward "the Black Prince," a hero of the Hundred Years' War. The Black Prince died a year before his father, Edward III, and Richard became king when he was 11 years old. Until he came of age, a regency governed England. When Richard was 14, the Peasants' Revolt occurred. Led by Wat Tyler, the peasants marched on London. Richard's counselors sent him out to make promises to meet their demands. The boy rode forth boldly and won the peasants' confidence, but the promises were never carried out (*See* Tyler, Wat.)

A group of ambitious nobles struggled to get power into their own hands. The group was led by one of Richard's uncles, the unscrupulous Thomas of Wood-

stock (later duke of Gloucester). Gloucester defeated the king's forces, led by Robert de Vere, earl of Oxford. The so-called Merciless Parliament, backed by Gloucester, then exiled or executed many of the king's friends.

When Richard was 22, he dismissed his advisers and took the government into his own hands. For eight years he ruled well. Then suddenly he became a despot. In 1398 he called a parliament in Shrewsbury and surrounded it with thousands of his archers. This parliament voted him the money he wanted and passed laws that made almost any opposition to the king treason. Richard then proceeded to imprison, exile, or execute his enemies and seize their property. One of those who suffered exile was his cousin Henry of Bolingbroke, son of John of Gaunt, duke of Lancaster.

When John of Gaunt died, in 1399, Henry Bolingbroke returned to England with a few followers to recover his vast Lancastrian estates. Thousands of Englishmen joined his army. Richard had gone off to Ireland to put down a rebellion there. When he landed in Wales, many of the soldiers he had brought with him deserted. Helpless, he surrendered to Henry and promised to give up his throne if his life was spared. Parliament accepted his abdication and conferred the crown on Henry, first of the Lancastrian kings (*see* Henry, Kings of England). Richard was imprisoned, and the next year, after a rebellion had broken out in his favor, he was reported dead. There is little doubt that he was murdered. His story is told in Shakespeare's 'Richard II'.

RICHARD III (1452–1485). Richard III ruled from 1483 to 1485. To gain the throne he had his two young nephews murdered. Two years later he was himself killed in battle. He is the subject of one of Shakespeare's tragedies, 'Richard III'.

Richard was the third son of the duke of York, a powerful feudal baron. When he was three years old, his father joined forces with the earl of Warwick and plunged England into the long and bloody Wars of the Roses (*see* Roses, Wars of the). The duke was killed in battle in 1460. The next year Warwick, called the "king-maker," succeeded in placing Edward, the duke's oldest son, on the throne as Edward IV. Edward named his brother George duke of Clarence and his brother Richard, then nine years old, duke of Gloucester.

Warwick soon quarreled with Edward IV and joined the duke of Clarence in a revolt against him. The king accused Clarence of treason and had him put to death. Richard advanced steadily in the king's favor. In his will, Edward appointed Richard protector of the kingdom and of his two young sons. When Edward died, in 1483, preparations were made for the coronation of his heir, the 12-year-old Edward V (*see* Edward, Kings of England).

The widow of Edward IV, Elizabeth Woodville, wanted to be regent for her young son. Her relatives and friends supported her claim. Richard escorted the boy to London and lodged him in the grim Tower of London, apart from his mother. He then spread charges that Elizabeth's marriage was illegal and claimed that her son therefore had no right to the throne. In a meeting of the Privy Council he accused the queen and her friends of witchcraft. Baring his left arm, he exclaimed, "See how they have wasted my body with their sorcery and witchcraft!" His left arm, says Sir Thomas More, who tells the story, was actually shrunk and withered, but so it had always been.

After this meeting Richard had several of the queen's relatives and friends executed and forced the council to declare him regent and protector. Then he took the queen's younger son from her and put him in the Tower with Edward. In July 1483 Richard was crowned king. After August the princes were never seen again. There is little doubt that Richard had them murdered—"for which cause," a contemporary account says, "he lost the hearts of the people."

The Wars of the Roses flared up again as soon as Richard came to the throne. In 1483 he put down a rebellion led by the duke of Buckingham and had the duke beheaded. In 1485 Henry Tudor landed in Wales with an army he had raised in France. Richard hastened to meet him. Before the two armies clashed, at Bosworth Field, many of Richard's men deserted him. In the thick of the battle, his friends urged him to flee; but cowardice was not in his nature. Fighting furiously, he fell at last mortally wounded. Tradition says that the crown he wore into battle was picked up and placed on the head of Henry Tudor (*see* Henry, Kings of England).

The Wars of the Roses ended with the battle of Bosworth Field. Under the strong Tudor monarchs, feudal anarchy gave way to a centralized government, and England entered the modern age. The year of Richard's death (1485) is therefore taken by historians as a convenient date to mark the end of the Middle Ages in England.

RICHELIEU (*rĭsh'ē-lụ*, French *rē-shē-lyû'*), **CARDINAL** (1585–1642). Armand Jean du Plessis, duke of Richelieu, was a cardinal of the Roman Catholic church. He was also for the last 18 years of his life chief minister of state to Louis XIII. During this period he raised France to the position of the foremost power in Europe. Physically he was frail and sickly, but in his red cardinal robes he appeared distinguished and commanding. By the force of his will he overawed all—including the king himself. He showed no mercy to his enemies, but he was loyal to his king and his country.

Armand de Richelieu was born in Paris of a poor but noble family in 1585. He was educated for the church and became a bishop at the age of 21. His eloquence attracted the notice of the queen regent, Marie de' Medici. She invited him to court, and in 1622 she secured for him the cardinal's hat. When her son, Louis XIII, came of age, Richelieu became his chief adviser. Louis was more interested in hunting and music than he was in the affairs of state. Although the king disliked Richelieu, he recognized his ability and allowed him to exercise almost unlimited power (*see* Louis, Kings of France).

HE LIFTED FRANCE TO POWER

Cardinal Richelieu was frail but so determined that he was called the "Iron Cardinal." Even Louis XIII obeyed him.

When Richelieu became adviser to Louis in 1624, he promised the king "to employ all my efforts and all the authority which it might please you to give me, to ruin the Huguenot party, to lay low the pride of the nobility, and to raise your renown among foreign nations to the point at which it ought to be."

Richelieu succeeded. In 1627 he besieged the town of La Rochelle, chief fortress of the Huguenots. He built a mile-long mole to blockade them from the sea. After a year of heroic defiance, the starving city surrendered to him. This defeat ended the political power of the Huguenots, but Richelieu let them keep freedom of worship and civil rights.

To humble the nobles was more difficult; but the ruins of many castles throughout France show how methodically and ruthlessly Richelieu struck at the nobles' power. He ordered the destruction or dismantling of every fortified place not needed for national defense. He also appointed royal officers to oversee the governors of the provinces and bring them under the control of the king.

Aids German Protestants

The chance to carry out his third plan came when religious and political wars broke out in Germany (*see* Thirty Years' War). Although Richelieu was a stanch Catholic, he used the war to make France a great power by aiding the German Protestants in their struggle against Catholic Spain and the Holy Roman Emperor. At first he gave financial aid to the great Protestant leader, Gustavus Adolphus of Sweden. Later he plunged France into the conflict. By this policy France was, at the conclusion of peace in 1648, the foremost power in Europe. It added to its domains the territory of Alsace, which later became one of the "lost provinces," restored to it by World War I.

Richelieu did not live to see the conclusion of the Thirty Years' War, but his work was ably carried on by his follower, the wily Mazarin. The war had cost France immensely in men and money, and when Richelieu died he was the most hated man in the country. Humiliated nobles and tax-burdened peasants joined in bonfire celebrations of their release from the tyrannical minister. The French people today, however, esteem him as one of the greatest of their rulers. "His fame," says one writer, "is cherished because he secured for France glory and power, and a foremost place among European nations."

Richelieu also made himself an imperishable place in the literary annals of France by fostering the great writers of his day and by founding the French Academy. (*See also* Gustavus Adolphus, King of Sweden; Huguenots; Louis, Kings of France.)

RICHMOND, CALIF. In 1899 the building of a rail line to the east shore of upper San Francisco Bay opened the site of Richmond to industry. It is now one of the busiest points on the bay. Important among its diversified industries are oil refining, automobile assembly, and the manufacture of plumbing and heating supplies, steel articles, asphalt roofing, chemicals, truck bodies, road-making machinery, prefabricated buildings, lumber and mill products, and hardware. During World War II the city had large shipbuilding yards. Since the war these have been converted to other industrial uses.

Richmond occupies a headland about eight miles northeast of San Francisco. It is connected with San Rafael, on the northwestern shore, by ferry. Richmond has both an inner harbor, with a channel dredged to float deepwater ships, and an outer harbor. Most of the vessels that dock at Richmond are engaged in coastal shipping. Some of the port facilities are municipally owned.

The first white man to occupy the Richmond site was Francisco Maria Castro, a Mexican army officer, who built a house here in 1823. George Ellis, who operated a schooner, established Ellis Landing on the site in 1859. The 1899 founders were John Nicholl and John Tewksbury. Richmond was incorporated a city in 1905. In 1920 it adopted the city-manager form of government. Richmond has a city auditorium and the West Contra Costa Junior College. Population (1950 census), 99,545.

RICHMOND, VA. In 1737, more than a century after the first colonists came to Virginia, Col. William Byrd founded a new settlement at the head of navigation on the James River, 90 miles from the sea. His friend, Major William Mayo, laid it out; and they named it Richmond because "its situation was like that of Richmond-on-the-Thames in England." Today this settlement is the chief manufacturing city of Virginia and a leading southern trading center.

Richmond's chief industry has always been tobacco products. One section is called Tobacco Row because of its tobacco factories. Other industries include paper mills, printing and publishing houses, and iron and steelworks. The Tredegar Iron Works supplied cannon for the Confederacy and has been operating since 1838. Suburban chemical factories specialize in rayon and cellophane. Richmond is the seat of the Fifth Federal Reserve Bank district. Ocean vessels use a deep-water terminal completed in 1940.

The town was built, like Rome, on seven hills. The city has grown until the city limits now include what was formerly the city of Manchester, across the James River. Richmond became the capital of Virginia in 1779 and was granted its city charter in 1782. In 1836 the first railroad started service. As the capital of the Confederate States during the Civil War Richmond was one of the chief targets of the Union army. The city was evacuated on April 2, 1865. The next day the citizens set fire to the cotton and tobacco warehouses and much of the city was destroyed. After the war the people rebuilt it into a modern industrial city.

A Rich Historical Heritage

Richmond has carefully preserved its mementos of earlier days. A large stone cross in Gamble's Hill Park commemorates the planting of a cross by Capt. Christopher Newport, Capt. John Smith, and others on an island near the Falls of the James in 1607. St. John's Church, where in 1775, Patrick Henry made his famous speech, ending with "Give me liberty or give me death," still stands.

The Capitol was patterned on a plaster model of the Maison Carrée, a Roman temple at Nîmes, France. Thomas Jefferson sent the design from France in 1785. In this building in 1807 Aaron Burr was tried for treason. The Confederate Congress was housed here from 1861 to 1865. In the rotunda stands Houdon's noted statue of Washington. Another statue of Washington, in Capitol Square, is one of the three most famous equestrian statues in the world.

Among the city's shrines and memorials are the Old Stone House, thought to have been built about 1737 and now a shrine in memory of Edgar Allan Poe; the home of Chief Justice Marshall, built in 1790; the Valentine Museum, built in 1812; and the Confederate Museum, which served as the White House of the Confederacy during Jefferson Davis' service as the Confederate president. Another cherished home sheltered the family of Gen. Robert E. Lee during his war years. A fine memorial of the Civil War is broad Monument Avenue, with imposing statues of Confederate leaders placed at intervals. Richmond's cemeteries contain the graves of Presidents James Monroe and James Tyler; Jefferson Davis, president of the Confederacy; John Marshall, fourth chief justice of the United States; Gen. J. E. B. Stuart; Com. Matthew Fontaine Maury, "pathfinder of the seas;" and many other prominent Virginians.

Richmond is an important educational center. The schools of higher learning include the University of Richmond, the Medical College of Virginia, the Richmond Professional Institute, the Union Theological Seminary, and the Virginia Union University for Negroes. In the city also is the Virginia State Library, authorized by the legislature in 1823. Richmond has a city-manager form of government. The city council consists of nine members, all elected at large. Population (1950 census), 230,310.

RIDDLES. "In at every window and every door crack, round and round the house and never a track." Can you guess this riddle? Your grandmother at your age probably guessed it and her grandmother before her. These puzzling questions called riddles have always been popular; and the wind has always been a favorite subject. The Wolof tribe of Senegal puts it in this way: "What flies forever and rests never?" The German riddle runs, "What can go in the face of the sun and leave no track?"

Riddles, like fables and folk stories, belong to all races and ages. Their guessing is an ancient game in which high prizes and heavy forfeits have been paid. The Bible has many of these old-time riddles. You will find them among the proverbs of Solomon, and in the fourteenth chapter of Judges there is a curious story of the riddle that Samson proposed to the Philistines. Among the ancient Greeks, also, the riddle was popular. It is found in the writings of their famous poets. Homer himself, legend says, died of chagrin because of a riddle that he could not guess.

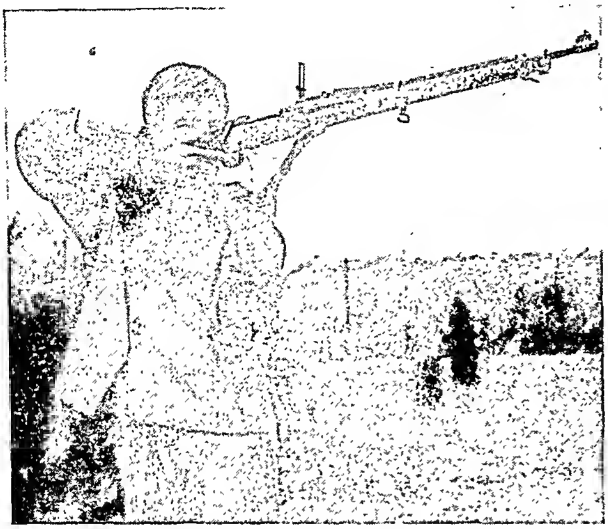
Among the well-known myths of Greece is the story of the Sphinx, a strange monster that crouched on a hill above the city of Thebes, waiting to kill men who passed by if they could not answer this riddle, which she put to them: "What is that which has four feet in the morning, two at noon, and three at night?" At last after many of his countrymen had perished because they could not guess it, Oedipus came and he answered, "Man. As a baby he creeps on hands and knees, in mid-life walks on two feet, in old age totters along with the aid of a cane, or third leg."

An ancient Norse myth tells of a riddle contest where the daughter of Thor was the prize. In the Middle Ages riddles were used merely as a pleasant pastime. Some have come down to us in an old collection called 'Amusing Questions'. It is well that solutions also are given, for who could guess such a riddle as "What is that that never was or never will be?" The answer to this is "A mouse's nest in a cat's ear."

Pun riddles are among the cleverest proposed today. "What is it that is black and white and red all over?" If "red" is spelled *read* it will give a clue, for the answer is "A newspaper." Another version of the "black and white and red all over" riddle has for its answer: "An embarrassed zebra."

The conundrum is related to the riddle. It is based on some odd resemblance between unlike things or their names. "What kind of fruit does the electric plant bear?"—the answer being "currents." Or, "When is a door not a door?"—to which you reply, "When it is ajar" (*a jar*).

LEARNING THE FOUR FIRING POSITIONS



This young marksman is learning the standing position. The body should be erect with the rifle butt held high up on the shoulder. For actual firing the gun sling is used in all four positions.

Good coaching will help develop good shooting habits. In the prone position, the left arm should be placed well under the rifle, the body lying at an angle of about 45 degrees to the rifle.

This class of beginners is practicing the kneeling position. The left arm should rest on the left knee with the elbow forward of the kneecap. The right elbow is held at shoulder height.

In the sitting position, the shooter should lean well forward with both arms resting between the legs. The telescopic sight, shown on the boy's rifle, is sometimes used for long ranges.

Riflery and Marksmanship. The sport of shooting at targets with firearms began in America during pioneer days. At turkey shoots and other festive gatherings frontiersmen competed for the honor of being the most accurate marksman with the long rifle. Contestants usually fired several rounds from three different positions—standing, on one knee, and prone—with the rifle supported by some form of rest.

Rifle marksmanship became a national sport after the Civil War. In 1871 the National Rifle Association was formed to standardize targets, firing distances, and contest rules. This group sponsored the first national rifle matches at the Creedmoor range on Long Island, N. Y. Interest in rifle shooting became so great that the annual championship matches soon attracted crowds of 100,000 or more.

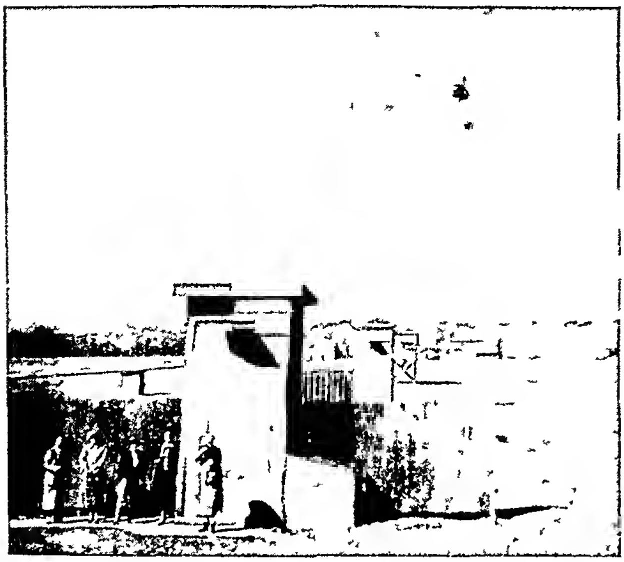
The early marksmen competed only with rifles. They believed that accurate shooting with pistols and revolvers required little or no skill. Many riflemen, however, gained a new respect for handgun shooting when they tried to duplicate the amazing exhibitions of accuracy put on by Buffalo Bill (William F. Cody) and later by Ira Paine (*see* Buffalo Bill). Finally in 1900 the National Rifle Association added pistol and revolver contests to its championship matches. Other matches are conducted by the United States Revolver Association at Springfield, Mass.

In 1902 Congress placed the National Rifle and Pistol Matches under the supervision of the United States Army. These matches are now held annually at Camp Perry, Ohio. Today riflery is a popular competitive sport in schools, colleges, and rifle clubs. (*See also* Ammunition; Firearms.)

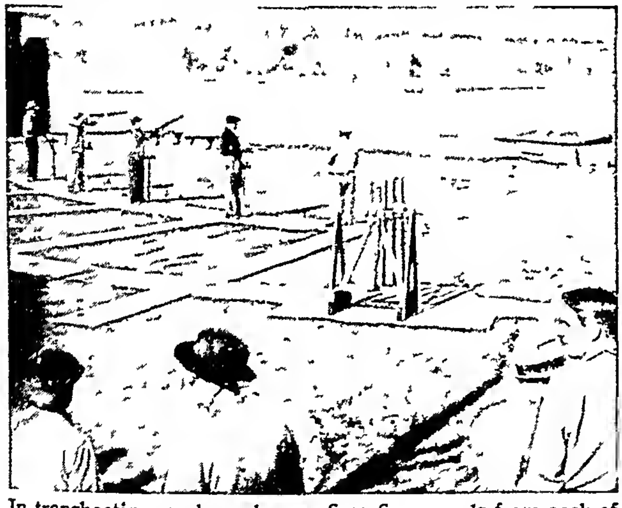
Firing Firearms for Record

The National Rifle Association divides shooters into five classes—master, expert, sharpshooter, marksman, and tyro (or beginner). Military and other .30-caliber rifles are fired at outdoor ranges varying

SHOOTING IMITATION GAME BIRDS



At firing station No. 1, a skeet expert shatters a bird (clay target) thrown from the high trap behind her. In skeet, 25 shots fired from eight different stations make up a round.



In trapshooting, each marksman fires five rounds from each of the firing positions occupied here. Trapshooters score most often at distances varying from 35 to 50 yards.

from 200 to 1,000 yards. The .22-caliber rifle is fired at 50-, 100-, and 200-yard ranges. Points totals are compiled from four shooting positions—offhand (or standing), kneeling (on one knee), sitting, and prone. The type of cartridge fired and the kind of sights used are fixed by regulations.

For pistol and revolver shooting the standard outdoor ranges are 25 and 50 yards. Matches usually consist of ten shots each at slow fire, timed fire, and rapid fire. Handgun matches are classified for .45-caliber military pistols, .32-caliber or larger center-fire revolvers, and .22-caliber rim-fire pistols and revolvers.

Practice Makes Good Marksmen

Before taking up any form of shooting every person should learn to obey the nine rules of gun safety listed in the article Hunting. (*See also* Safety.)

To become a "good shot," first practice getting a correct sight picture—that is, the bull's-eye in the target should float just above the tip of the front sight. The front sight is centered in the opening of the rear sight. Next learn to adjust the gun sling so that it supports the left arm and helps hold the rifle steady. On the firing line, face the target and then do a half turn to the right before assuming any position (standing, kneeling, sitting, or prone). Shift the body so that the rifle points naturally toward the target.

The actual firing is done in four steps: (1) take up the slack in the trigger; (2) hold the breath; (3) aim carefully; (4) squeeze the trigger with a slow and steady increase of pressure. A good shot can always describe the sight picture at the instant the rifle fired—centered, high, low, or to one side.

Marksmanship with a Shotgun

The sport of trapshooting began in England as a substitute for game-bird hunting. It was introduced into the United States about 1880. In trapshooting, the marksman fires a shotgun (usually 12-gauge) at a saucer-shaped target tossed into the air by a spring mechanism, or *trap*. The target, or *clay bird*, leaves the trap at an unpredictable angle and elevation, imitating the swift flight of a quail. The bird is made of an earth filler and pitch binder and shatters when struck by shotgun pellets.

Skeet, another form of shotgun marksmanship, began in the United States about 1910. In this sport, the targets are also clay birds but the gun may be of any gauge. The birds are sprung from two traps, one at ground level, the other nine feet high. Seven firing stations are arranged in a semicircle near the traps; an eighth station is midway between the two traps. At each station, the marksman fires at least one shot at a bird from the high trap and one at a bird from the low trap.

RIGA (*rē'gȧ*), **LATVIA**. The city of Riga stands at the head of the Gulf of Riga, an arm of the Baltic Sea. It was founded by German merchants of the Hanseatic League in 1158. It still has the air of a medieval German city, with high warehouses, spacious granaries and cellars, and narrow winding streets. In contrast, the suburbs are quite modern, with wide boulevards and many apartment houses.

Riga's port is the second largest on the Baltic (Leningrad is first), but the harbor is closed by ice in winter. Canals connect Riga with the basins of the Dnieper and Volga rivers in Russia. The city is the home of Latvian University and several trade and technical schools.

Riga was the capital of Latvia while it was an independent nation (1918–40). Textiles, wood pulp, and cellulose products were manufactured in this thriving commercial city. During World War II, when Latvia became a part of Russia, most of the Germans who were responsible for its commerce and industry fled. Russian police deported others suspected of being out of sympathy with Communism. Riga is now the capital of the Latvian Soviet Socialist Republic. Its population, made up mainly of Letts and Russians (1947 estimate), 390,000.

RILEY, James Whitcomb (1849–1916). People who remember a pleasant childhood on a farm or in a small town read and like the poetry of James Whitcomb Riley. This Indiana poet wrote from the memories of his own happy boyhood. His verses recapture the sports, the fun, and the simple good times enjoyed by adults and children of his day. Riley has never been regarded as a great poet, but his work holds a valuable and readable record of the American past.

Riley was born Oct. 7, 1849, in Greenfield, Ind. He was the third of six children of Reuben A. Riley, a lawyer and popular local orator. "Buddy" Riley went to school until he was 16, but the only subject that interested him was reading. He began with the McGuffey Readers and went on to the standard poets and novelists. He learned much by accompanying his father to the county courthouse and listening to the colorful colloquial speech of the farmers who had come "to law."

After Riley left school, he earned his living as a sign and ornamental painter. For two summers he and several other young men formed a traveling company of sign painters, called the "Graphics." As Riley later described it, they "covered all the barns and fences in the state with advertisements."

Before he settled down he also toured with a medicine show company as a musician and storyteller. Back in Greenfield, he worked on the local paper, then took a job as reporter in nearby Anderson, Ind. Here he perpetrated a now-famous hoax. He felt, with some justice, that the public would acclaim almost any work if its author were already famous. He composed a poem called 'Leonainie' in the style of Edgar Allan Poe, and the *Kokomo Dispatch* printed it as a hitherto unpublished Poe masterpiece. After scholars and collectors requested the original Poe manuscript, he revealed the hoax.

Soon after, he started to work for the *Indianapolis Journal*, where he spent eight years. He also contributed poems to the paper under the pen name of "Benj. F. Johnson of Boone," supposedly a farmer with a gift for turning his rustic language into pleasing verse.

These were collected in a little paper-backed volume of 50 pages as 'The Old Swimmin' Hole' and 'Leven More Poems', published 1883. Within a few years, Riley's books of verse and prose sketches were bringing him national fame. Poems such as 'Little Orphant Annie' were read and recited across the country. Like Mark Twain, he became a platform entertainer, giving humorous readings from his own works. He was enormously successful in this as well.

Riley never married. He maintained a home on a quiet street in Indianapolis, where close friends lived with him. Today the house may be visited by tourists; his boyhood home at Greenfield is also open to the public. His last years brought him several university degrees and other honors. He died July 22, 1916. On his birthday anniversary, the state of Indiana annually holds a James Whitcomb Riley Memorial Program.

Riley's poems, complete in six volumes, were published in 1913. His best known books are 'The Old Swimmin' Hole' (1883); 'Afterwhiles' (1887); 'Pipes o' Pan at Zekesbury' (1888); 'Old-Fashioned Roses' (1888); 'Rhymes of Childhood' (1890); 'Green Fields and Running Brooks' (1892); 'Armazindy' (1894); 'A Child World' (1896); 'Rubaiyat of Doc Sifers' (1897); 'Home Folks' (1900); 'An Old Sweetheart of Mine' (1902); 'Out to Old Aunt Mary's' (1904).

RIO DE JANEIRO (*rē'ō dĕ ǵa-nā'rō*), Brazil. Few cities have a setting as beautiful as that of Rio de Janeiro, capital of Brazil. Crescent-shaped beaches border the deep blue of its harbor, Guanabara Bay, and the adjacent Atlantic Ocean. The rich green of tropical vegetation clothes the islands sparkling in the bay and the hills that rise from a narrow coastal plain. At the entrance of a harbor "big enough for all the navies of the world" stands "Sugar Loaf" (*Pão de Açúcar*), the cone-shaped rock that is Rio's most famous landmark. An aerial trolley carries visitors to the top to enjoy the spectacular views.

The people of Rio, nicknamed Cariocas, have built a city worthy of the setting. Handsome parks, plazas, and boulevards along the water greet visitors arriving by ship or landing at Santos Dumont airport, which occupies a peninsula of filled land near the heart of the city. From Praça Mauá, near the wharves, the broad Avenida Rio Branco cuts through the business district to the Praça Paris. There its traffic follows the scenic Avenida Beira Mar and other bayside boulevards south to Copacabana beach, fringed by fashionable skyscraper apartments and hotels.

Rio's architecture is varied. Churches and palaces built when Brazil was a Portuguese colony or an empire reveal a Latin lavishness of ornament. Recent buildings tend to be severely modern.

A special feature of the city is its multicolored mosaic sidewalks—a Portuguese fashion. The many parks

BRAZIL'S MINISTRY OF EDUCATION

Rio architects adapted this modern building to their warm climate by creating adjustable louvers to shade the huge windows.

are brilliant with tropical flowers. Palms wave their branches 150 feet above the ground, and tall bamboos interlock over the walks and shield strollers from the sun. Especially interesting are the Botanical Gardens, where flowers from all parts of the world are cultivated, and the "Hunchback," or Corcovado, a 2,310-foot granite peak whose summit offers a magnificent view. On the peak is a famous concrete statue of Christ, 125 feet in height.

Since 1903 the city has been largely rebuilt at great expense. Sanitary reforms have transformed it from a port dreaded by sailors because of yellow fever to one of the most healthful of tropical cities. The harbor, naturally one of the finest in the world, was dredged to make a broad channel along the new great stone quay deep enough for the largest steamers. Hundreds of buildings were torn down in the business section to widen the streets.

Coffee is the principal export, and imports consist chiefly of food and manufactured articles. The most important industries are flour and textile mills.

According to Portuguese writers, the name Rio de Janeiro ("River of January") was given to the bay by a Portuguese captain who entered it in January 1502 and thought it to be the mouth of a large river. Population (1950 census, preliminary), 2,335,931.

RIO GRANDE (*rē'ō grănd'*, Spanish *grăn'dē*). One of North America's longest rivers is the Rio Grande in southwestern United States and northeastern Mexico. This 1,800-mile river rises in the San Juan Mountains in southwest Colorado and then flows south through central New Mexico. It forms the boundary between Texas and Mexico for 1,250 miles and then it empties into the Gulf of Mexico. The river drains 210,000 square miles, about equally divided between the two countries (for map, *see* United States). The chief tributaries in the United States are the Pecos and Devils rivers, and in Mexico, the Rio Conchos, Rio Sabinas, and Rio San Juan.

Rio Grande means "big river" in Spanish. However, the Mexicans have another name for it—Rio Bravo (*brä'vō*), or the "brave river." The river passes through a wide variety of land and climate. At its origin, the Rio Grande is a small mountain stream. It soon becomes a torrent rushing between canyon walls. Then for much of its length it is a sluggish stream, often a mere trickle choked by shifting sand bars. Generally it is not deep enough for navigation.

The basin begins in the Rocky Mountains, becomes a semidesert, and ends as a delta. Rainfall is plentiful in the mountains and on the coastal plain near the mouth, but the greater part of the basin lies in an arid region. Floods occur when mountain snows melt and during the infrequent, but torrential, rains along its middle section. Soil erosion and silting are serious problems. Big Bend National Park is in the wide U-shaped loop in southwestern Texas. Spectacular is its 1,800-feet deep Santa Elena Canyon, or Grand Canyon of Santa Helena.

The Rio Grande has often been the cause of international disputes. When the United States annexed Texas, Mexico would not accept the river as a boundary, and the Mexican War resulted. By the Treaty of Gaudalupe-Hidalgo in 1848, "the middle of the river following the deepest channel" became the boundary from El Paso to the sea. The river constantly shifts its course and creates problems of land ownership. It makes many new *bancos* (islands). Those smaller than about a square mile or with less than 200 inhabitants, near the right bank pass to Mexico; those near the left bank, to the United States. The International Boundary and Water Commission, United States and Mexico, created in 1889, decides boundary questions.

At times during the year, the river shrinks so that it can be forded by smugglers, criminals, or "wetbacks" (illegal immigrant farm workers). The United States border patrol watches for offenders.

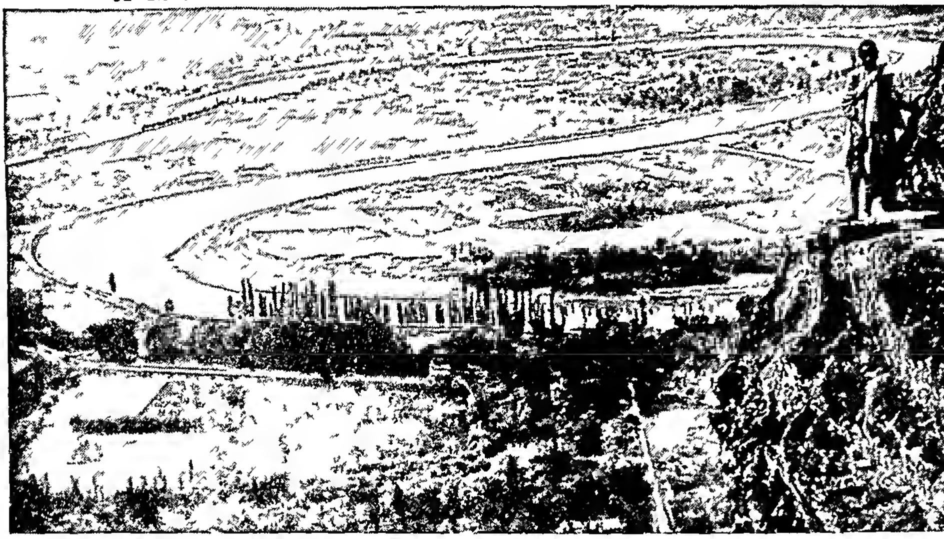
Drawing off irrigation water from the upstream stretches has caused water shortages farther down. In the treaty of 1906, the United States agreed to deliver annually 60,000 acre-feet of water from the river to Mexico. Elephant Butte Dam, 120 miles above El Paso, was built in 1916 to ensure delivery of the water. The huge dam irrigates about 180,000 acres, controls floods, and generates power in a federal reclamation project along the upper river. About 22 miles downstream is Caballo Dam, completed in 1938. There are irrigation works on tributaries in Mexico and in the United States. El Vado Dam is in New Mexico on the Rio Chama. Across the Pecos are Alamogordo, Avalon, and McMillan dams in New Mexico and Red Bluff Dam in Texas.

Under the treaty of 1933, the Commission straightened the Rio Grande and built levees. Texas, New Mexico, and Colorado in 1938 made an agreement to divide the flow of the upper river. The 1944 Mexican Water Treaty provides for distribution of water of the lower river and for dams. In 1953 the presidents of the United States and of Mexico dedicated Falcon Dam, built about 75 miles below Laredo.

RIVERS AND INLAND WATERWAYS. To man, rivers are of tremendous importance. Farms fill their valleys and flood plains, and cities rise on their banks to take advantage of river transportation and water power. Rivers are equally important in nature. They drain the land of its surplus water and carry it to the sea. Along with this drained water go billions of tons of mud, rock, and minerals. Rivers are more important than all other natural forces in shaping land surfaces. They cut up high plateaus, creating rugged mountains; and in the course of ages they drop these mountains, bit by bit, into the sea.

Every river system tries to carry to the sea all the land of its basin above sea level. Few rivers accomplish this, for the river itself passes through a cycle of evolution, from youth to old age. As it gradually cuts down its steep slope, it changes from a rapid stream in a narrow valley to a wide sluggish one with little erosive power. It may take as long to wear away the last few feet above sea level as all the previous thousands of feet.

A MEANDERING RIVER IN THE FAMOUS VALE OF KASHMIR



The Jhelum River winds lazily through the Vale of Kashmir, a wide valley The river's graceful curves suggested to the weavers of Kashmir the loop design used in Paisley shawls. The hill (right), 1,000 feet high, is called the Throne of Solomon On this hill stands the temple made famous by Thomas Moore's poem 'Lalla Rookh'. The Vale is a great oval basin, the bed of a vanished lake. It lies below snowcapped peaks in the state of Kashmir, the northernmost part of the Indian peninsula About 25 miles below the Vale, the Jhelum widens and forms Wular Lake and marsh. It is a typical meandering river. The broad, sweeping curves are called *ox bow* or *meander* curves

The *bed* of a stream is the surface upon which it flows, and its *banks* are the sides which hold it in bounds. A *river system* includes a main stream and its branches, or the tributaries which flow into it. A *river basin* is the territory drained by the river and all its tributaries. A *divide*, or *watershed*, is the high land between two rivers which causes the ground water to flow toward both streams. Where a river enters the ocean on a sunken coast line, the sea backs up into the mouth and it becomes a "drowned" river; a V-shaped bay, called an *estuary*, is thus formed. Many important harbors are large estuaries.

We commonly speak of only one "source" of a river; but a well-developed river system has as many sources as a tree has branches, all of which ultimately reach the trunk that empties into the sea. The water of rivers, furnished by rain and snow, comes at first from the sea by evaporation, or in less degree from lakes and other rivers. When rain falls on an uneven slope it is gathered into many little rills which follow the depressions in the surface, and immediately gorge making begins Much rain, especially upon level ground, soaks into the soil, but later seeps into the rivers which have cut their channels deep enough, or comes up to feed streams in the form of springs. Those rivers which do not have access to ground water have usually only an intermittent flow, unless their sources are in snow or ice fields or lakes.

A Rushing Start and a Placid Finish

At its source in the mountains the bed of a stream is steep and the swift river tears away everything that is in its path, causing rapids where it rushes over a rocky bed, or high waterfalls when it tumbles over cliffs. As the river leaves the mountains, however, the gentler slope of the land makes it less rapid and gives it power to carry only small stones, gravel, and mud. Near the ocean the slope of the bed diminishes still more, and the valley becomes a wide plain in which the river swings to right and left in great curves or "meanders," laying down most of the burden which it gathered in the mountains. (The name *meander* comes from the river Meander — now called the Menderes — in Asia Minor.) As the flowing river unites with the standing water of the sea, even the finest sand sinks to the bottom, and a plain is built up called a "delta," from its resemblance to the Greek letter Δ.

At times of heavy rains, or in the spring when the snow melts rapidly, the shallow channel in the lower course of a river is unable to contain all its water, which then spreads over the surrounding country like a vast sheet. When the water subsides it leaves a thin layer of sediment behind, which in time builds up a broad flat "flood plain," like that along the Nile and the Mississippi, where the soil is extremely fertile High levees are often built along such rivers to protect the countryside. But such control cannot be permanently successful, for the sediment deposited by the river gradually raises its bed above the ground on either side, and in time the water overflows the levees. The Hwang Ho, or Yellow River, in China, called "China's sorrow," is thus constantly changing its channel. (*See* Hwang River.)

Such is the typical river, of which there are many variations. Where the movement of the land is downward there are no deltas, but drowned river valleys, as in northeastern America. Floods cannot occur on rivers like the St. Lawrence, which have their flow equalized by lakes. In arid countries many rivers do not empty into the ocean, but end in deserts where they sink into the ground or evaporate.

In the history of America, the rivers have played an important part. The streams were the gateways that allowed the early explorers and the colonists to penetrate the continent, for on land they were confronted by thick and almost trackless forests. Thousands of hunters entered the interior by the rivers and lakes to obtain furs.

In colonial days the rivers served a double purpose, enriching the soil for the farmer and providing a means of transporting his products to points from which they could be shipped to Europe, thereby

saving the heavy expense of overland freighting. When small mills began to take the place of the home in manufacturing, the rivers and streams took on another important economic aspect, becoming the sources of power for the factories. These waterways also affected social conditions, for they made communication easier, and settlements naturally grew up about shipping and manufacturing points.

The completion of the Erie Canal aided the growth of the West in days before the railroads were built. During the early years of the railroads, waterways lost their importance, but recently the cheapness of water transportation has caused renewed interest.

Great American Waterways

Perhaps the most important inland waterway in North America today is the Great Lakes-St. Lawrence system, including the canals at Sault Sainte Marie (one on the Canadian and two on the American side of the St. Marys River) and the Welland Ship Canal. This waterway, developed by the United States and Canada, may some day be deepened until great ocean liners can come all the way up the Great Lakes to Chicago and Duluth. (*See also* Canals; Great Lakes; Sault Sainte Marie; Welland Ship Canal.)

A second great development is the Mississippi River system. A nine-foot channel exists on the Mississippi from Minneapolis to Baton Rouge, and on the Ohio from Pittsburgh to the Mississippi. A nine-foot channel, authorized by Congress in 1945, is almost complete on the Missouri from Sioux City to the river's junction with the Mississippi.

The Great Lakes-St. Lawrence system and the Mississippi system are connected through the Illinois Waterway system. This leads from Lake Michigan through the Chicago River, the Chicago Drainage Canal, the Des Plaines River, and the Illinois River to the Mississippi River near Alton. This waterway was completed in 1933 by co-operation of the federal government and the state of Illinois.

Waterways along the Coasts

Also counted as inland waterways are the coastal bays and canals along which small boats can pass through protected waters from Boston to Florida by way of the Cape Cod Canal, the Chesapeake and Delaware Canal, the Chesapeake and Albemarle Canal, and the Dismal Swamp Canal. A similar intracoastal system follows the Gulf coast from Apalachicola, Fla., west to Brownsville, Tex. The two may some day be connected by a canal through Florida.

Of the 25,000 miles of river which are classed as navigable and therefore under federal control, about 4,000 are now actually usable. Plans call for an expansion to about 9,000 miles. Along these waterways barges, steamboats, and even small passenger vessels can travel. (*See also* Canals; Floods; Valley; and articles on important rivers.)

ROAD RUNNER. A familiar and amusing bird of the deserts is the road runner. It lives among the sands and cacti of the southwestern United States and Mexico. The name comes from its habit of dashing along desert roads at a speed that automobiles have clocked at 15 miles an hour. It flies very little, preferring to travel by running and by fast, gliding jumps. The bird presents a comical appearance as it sprints along with neck and head stretched forward, crest raised, short wings outspread, and long tail jerking up and down. When it tires, it abruptly turns aside into the brush and brakes to a sudden stop by throwing the tail over its back.

It is a large bird about two feet long, including the foot-long tail. The head has a bristly crest. A bare space around the eyes is orange and blue. The coarse feathers are a streaked brown color, tipped with white, changing to bronzy-green in the tail.

The nest is placed in cactus or other low-growing, spiny plants. It is made of sticks lined with soft plant materials, feathers, or snake skins. The four to six eggs are white or yellowish. Snakes are an important food, and many tales are told of the bird's battles with rattlesnakes. Its varied diet also includes lizards, centipedes, mice, rats, scorpions, tarantulas, and cactus fruit. Road runners are easily tamed and make attractive pets. It is the state bird of New Mexico. (For picture in color, *see* Birds.)

Road runners belong to the family *Cuculidae*, which includes the cuckoos and anis. The scientific name is *Geococcyx californianus*.

A ROAD RUNNER AT THE NEST

The road runner nests in spiny cactus thickets in the deserts of the Southwest. It is a large chickenlike bird with an appetite for snakes, centipedes, and insects.

The historic Appian Way near Rome is a 2,000-year-old road that is still in use today. A recent study made by American engineers showed that it is in better condition than many modern roads and streets. Roman roads had extremely deep foundations. For many years these deep foundations were thought unnecessary. Now they are believed essential to withstand the pounding of heavy traffic.

GOOD ROADS *and* CIVILIZATION

ROADS AND STREETS. Every time you leave your home to go to school, to go downtown to the store, or to travel just a few blocks to visit a neighbor you use roads or streets. You probably do not think much about them. They are a part of your daily life that you simply take for granted.

Roads and streets form a vast network that links neighbor with neighbor, town with town, city with city, and even country with country. In the United States alone this network totals more than 3,300,000 miles. Most of the improved highways in this network have been built within the past 30 years.

Today America is a nation on wheels, but our grandfathers remember when there were no automobiles and few paved roads. Now automobiles, trucks, and buses travel 500 billion miles a year to carry us, our goods, and services everywhere in all kinds of weather.

In American cities a generation ago most people lived on a streetcar line or in walking distance of their work or school. Now millions of people live in the suburbs and work in the cities many miles away from their homes. Automobiles and commercial buses take them to work in town, to the drive-in shopping center, or to school. Trucks bring household supplies and many other goods and services directly to the consumer's door.

Life has changed in rural areas too. Because nearly the entire population lives on or within a few miler of a surfaced road, friends and markets may be far away in miles but close in minutes. The trip to town takes an hour instead of all day. Crops can be hauled to markets and farm supplies brought back with no fear of getting stuck in the mud. Good all-weather roads have made it possible to close

the local small schools and to replace them with improved consolidated schools (*see* Farm Life).

When the mailman had to drive his buggy through the mud and dust, rural mail delivery was slow and difficult. Today 30,000 mail carriers travel 1½ million miles of rural roads every day. This makes rural mail service as regular as that in the city where the mailman delivers to only a few blocks on city streets.

Modern Traffic Problems

Today the entire population of America could be carried by its motor vehicles. Yet the automobile is a relatively new device (*see* Automobile). Without excellent roads and streets it could never have become a common means of travel. The improvement of roads and streets, however, has not kept pace with the tremendous increase in the number of vehicles. Traffic problems have become serious. Motor traffic of trucks, buses, and passenger cars between cities and from the suburbs chokes the roads. In the cities traffic is very heavy and seems to want to go in all directions at once. To keep traffic moving as smoothly as possible, cities need many regulations, traffic signals, and police officers to direct traffic (*see* Safety; Police).

Stop signs and traffic control signals on streets where traffic is extremely heavy may themselves cause serious tie-ups. To combat this and other traffic problems many of the newer towns and cities have a major street plan. This may include the widening of streets and rerouting of through traffic to arterial highways for easier and quicker travel from the country to the heart of the city. Streets in residential neighborhoods with low, or light, traffic loads can be much narrower (*see* Cities).

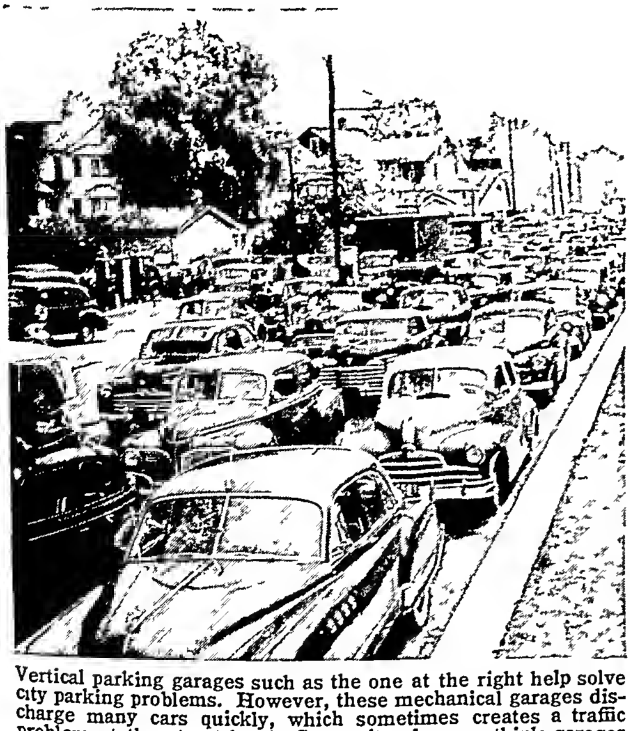
Streets in the older cities are laid out like spokes in a wheel, with the business district the hub at the center. The spokes bring traffic into the business center from the intercity and interstate highways and from the nearby suburbs. Cross-town streets connect these spokes to link together different parts of the city. Other streets are used for transportation to the houses built along them.

In newer cities streets are laid out in a rectangular, or "checkerboard," pattern. When this system of *grid pattern* streets is followed too rigidly traffic problems again result. In some of our most modern suburbs the houses are not built along streets. Residents park their cars in a central parking area and walk to their homes, which are situated in groups around a park area.

Businesses were first built in the center of cities because that was the easiest point for the largest number of people to reach. Now, because of downtown traffic problems, some merchants are finding suburban shopping centers profitable. Other businesses keep offices downtown but have their factories or warehouses in suburban or rural areas. These are forms of *decentralization* to permit easier access and parking for customers and employees.

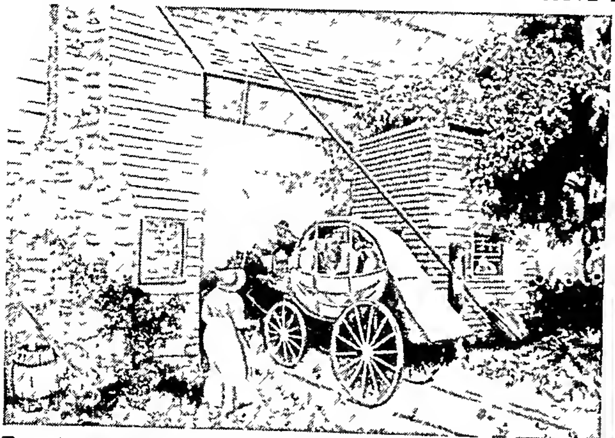
City planners believe that other ways must be found to solve traffic problems. One way is to separate car and truck traffic either by not allowing cars and trucks to enter the center of the city or by dividing up the times when they can enter. Curb parking can also be banned, or the all-day

SOLVING CITY PARKING PROBLEMS BY PARKING IN THE SKY

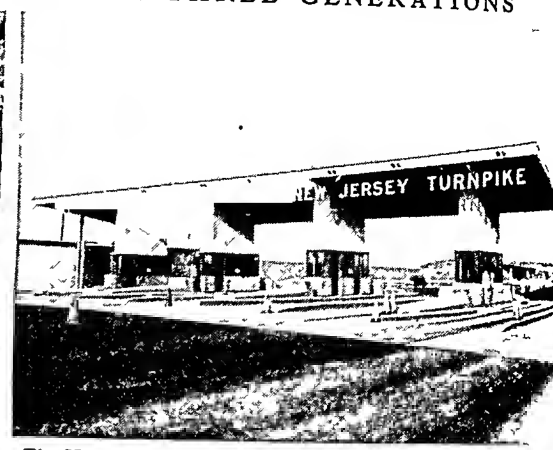


Vertical parking garages such as the one at the right help solve city parking problems. However, these mechanical garages discharge many cars quickly, which sometimes creates a traffic problem at the street level. Some city planners think garages should be built on highways rather than on narrow side streets.

FROM TURNPIKES TO TURNPIKES IN THREE GENERATIONS



Turnpikes have been popular twice in America, both times near the mid-century. Above is a toll gate on the Maysville Turnpike, which ran through Kentucky's Bluegrass region in 1830.



The New Jersey Turnpike was completely opened to motorists in 1951. As many cars travel along this superhighway across New Jersey every six months as Detroit manufactures in a year.

parker can be encouraged away from the center of the city by providing parking areas at the city's edge. Buses and streetcars can then provide mass transportation to and from stores and businesses.

The lack of parking space is a problem in all cities. Parking meters have helped make good use of available space along the curbs by limiting parking time. More space is provided by off-street parking and, in the larger cities, by parking garages.

Rezoning may also help solve traffic problems. This is a method of redesigning cities by strictly controlling the use of land and buildings. Rezoning may create cities of the future surrounded for 50 miles or more by small residential areas. Buildings in downtown sections would be farther apart than they are now, with wider streets and much more parking space. Sidewalks might be above the street level.

Traffic outside the cities also has caused serious problems. Many roads are not large enough or in good enough condition for the heavy volume of traffic they carry. The United States Bureau of Public Roads is working with the state highway departments to develop and further improve the national system of interstate highways.

The best of the modern roads have features essential to fast and safe driving for large traffic volumes. These are called *express highways*, *expressways*, *parkways*, *freeways*, or *thruways*. An expressway is usually a divided highway with two or more lanes on each side of a separating strip of grass or shrubbery. Entrance and exit are usually allowed only at selected places, with ramps and overpasses or underpasses arranged to avoid intersections and cross traffic. This is known also as a *limited access highway*. A *parkway* is a limited access highway through a park or along which there are publicly owned strips of land. Usually trucks and other commercial vehicles are not permitted to use a parkway. A *freeway* is a limited access highway open to all types of traffic.

Return of the Turnpikes

Toll roads, or *turnpikes*, which charge a fee for use have become important again in the better roads movement. This is the second time they have appeared on the American scene.

Turnpikes were first introduced in Europe during the late 18th century when roads were privately owned and fees collected for using the roads. Poles armed with sharp spikes called pikes stopped the traveler at toll stations. The poles were turned aside after payment, hence, the term *turnpike*.

Turnpikes were first introduced into America in 1785. By 1850 there were over 400 in New York State alone. They were the first improved roads in this country. For one type of surface, trunks of trees were placed across the roads and allowed to settle into the roadbed. These were called "corduroy" roads.

Some turnpikes were surfaced with wooden planks. First used in Russia, they were introduced into North America by Sir Charles Edward, governor general of Canada. He built a few miles of plank road near Toronto in 1836. The first plank road in the United States was built in 1845–46 from Syracuse, N. Y., to Oneida Lake, a distance of about 14 miles.

Most of the turnpikes were between the larger cities, such as the Lancaster Turnpike between Philadelphia and Lancaster, Pa. It was built between 1790 and 1794 and was the first important *macadamized* road in America.

A Scottish engineer, John L. MacAdam (1756–1836), devised the road surface which bears his name. It was made of loosely packed broken stone using water as a binder. Today macadamized surfaces are generally mixed (impregnated) with hot asphalt, tar, or some similar binder. This type of road surface is called *bituminous macadam*.

Turnpikes fell into disuse by the middle of the 19th century. The railroad had arrived and proved to be a better means of travel over long distances. Canals too took passenger and freight business from the turnpikes. There followed a period known as "the Dark Ages of American Roads." (*See also* Railroads; Canals; Transportation.)

The Pennsylvania Turnpike, which was opened in 1940, was the first of the modern turnpikes. This

great highway extends from a point near Valley Forge, Pa., westward for 327 miles to the Ohio border.

World War II interrupted the turnpike movement, but at the end of the war a toll road rush began. By 1953 toll roads in operation, under construction, approved, or proposed totaled 6,000 miles in 26 states. Toll road development has been greatest in the congested eastern part of the United States, but the movement has also spread to most other parts of the country.

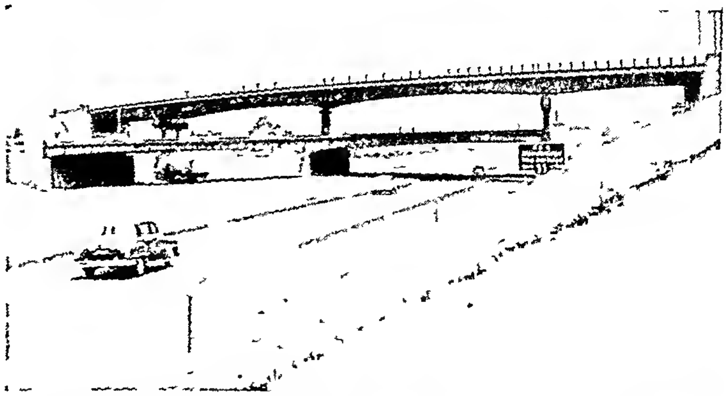
Types of Modern Pavement

Engineers use a variety of pavements in modern roads and streets. Their choice of materials is based on such considerations as the expected volume of traffic, climatic conditions, and cost. Concrete and asphalt, which are the two most widely used kinds of *high-type paving surfaces*, are described in the Cement and Asphalt articles. American road builders have used concrete since 1900. It was introduced in Scotland about 1865. Asphalt was first used in the United States to pave Pennsylvania Avenue in Washington, D. C.

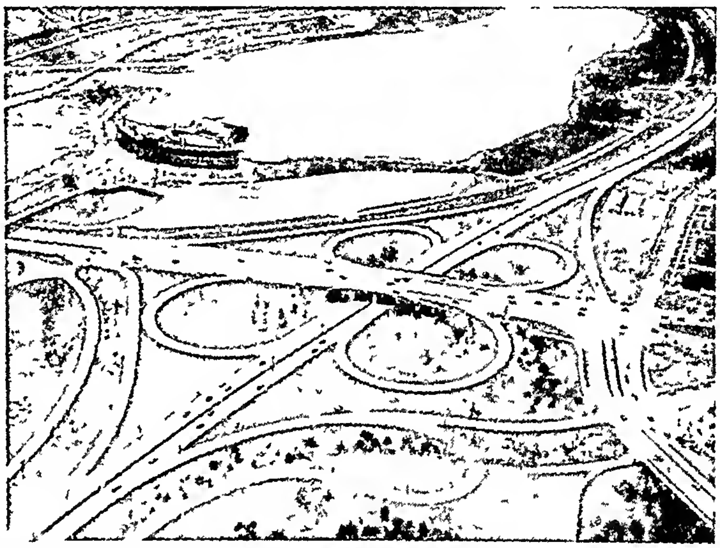
Cobblestones, brick, wood, and granite blocks have also been used for road and street surfaces. Where traffic is too light to justify expensive concrete highways yet too heavy for stone or gravel roads, "soil-cement" is often used. In this kind of paving, soil is mixed with cement and rolled. Experiments have been made in the use of plastic and rubber road surfaces.

Of the more than 3,300,000 miles of rural roads and city streets in the United States, about 1,300,000 miles are improved or graded and drained dirt roads. Another

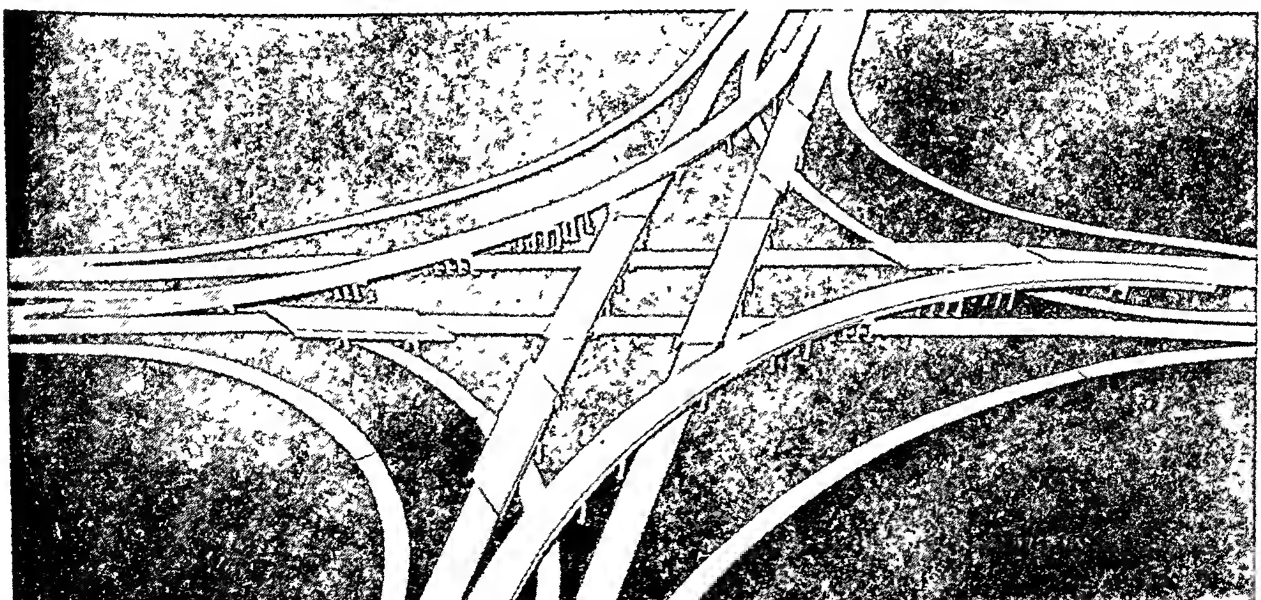
HIGHWAYS OF TODAY AND TOMORROW



Modern highways have safety features that reduce the possibilities of accidents at dangerous intersections. The above trilevel structure shows how cars from three different highways can cross at an intersection without having to pass directly in front of each other.



The "cloverleaf" system of entrance and exit is one of the features of a limited access highway. Cars enter and leave the highway with the stream of traffic, never against it. Note also the elevated structure of one highway to eliminate stop lights at the intersection.



This is a model of a high-speed traffic interchange planned for a Detroit expressway. This type of interchange permits drivers to change from one intracity highway to another with no change in speed. There are no crossroads, stop lights, or congestion.

1,183,000 miles are surfaced with soil-cement or with gravel or crushed stone. About 815,000 miles, or a little more than one fifth, are "paved." Of these about 425,000 miles have tar or asphalt surfaces and 388,000 miles have portland cement, asphaltic concrete, brick, or stone block surfaces. Many of these surfaces are far from new or adequate. About 265,000 miles of surfaced state highways are less than 20 feet wide. Only approximately 5,000 miles are divided highways with four or more lanes.

The more important rural roads in America's network of roads and streets are primary state highways. They are under the control of the state highway departments. Other rural roads are called secondary, feeder, or farm-to-market roads. Their improvement is supervised by county, township, and other local officials. Some states, however, place all or part of their secondary roads under the state highway department. City streets and highways are largely under the control of city officials. Some city streets that are extensions of primary state highways are under state highway department control.

How Roads and Streets Are Paid for

Federal money for highway construction is given to the states in proportion to their area, population, and rural mail route mileage. In order to get this money, each of the states has to pay at least half the cost of the roads built with it. This is called a "matching fund." States get money for building and maintaining their roads from gasoline taxes, license fees, and other highway users' taxes on motor vehicles. They also issue bonds which are paid off with gasoline taxes and license fees. Twenty-four states now have laws which prevent money raised for road building from being used for other purposes.

The federal-aid system includes approximately 7 per cent of the total highway mileage in each state. Federal engineers and state highway departments work together in planning routes. The states build the roads. The states also build many sections of the highway system without financial assistance. Other county and township roads and city streets are paid for with state and local funds. The most important city streets are frequently under the federal-aid urban system and can be improved with federal-aid funds.

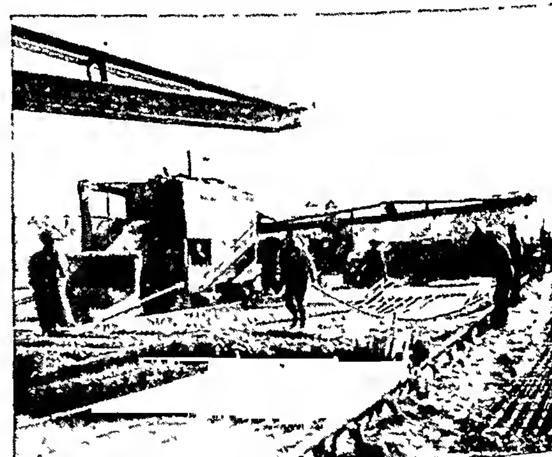
Beginnings of Federal Aid

The bicycle and the automobile were mainly responsible for the first federal-aid to road building. In the late 19th century several million cyclists, members of the Wheelmen of America, set up a demand for better roads. The demand increased with the coming of the automobile, which later led to the Good Roads Movement of the 1920's. The success of the latter movement with its slogan, "Get the Farmers Out of the Mud," made possible our present automotive development.

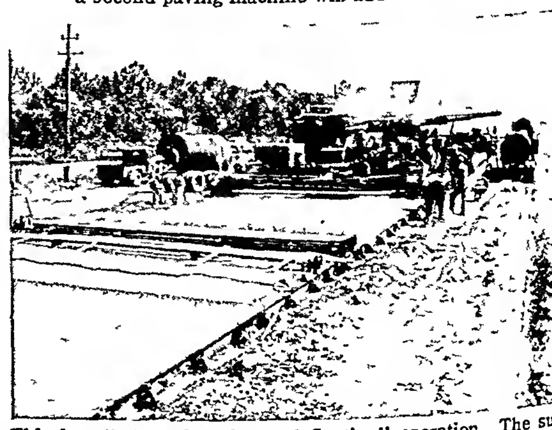
The first Federal Aid Road Act, or Tice Law, was passed July 11, 1916. It was followed by laws that gave federal aid to the construction of 1,384,000 miles of surfaced rural roads. These

A CONCRETE PAVING JOB

Heavy machinery that does the work once requiring hundreds of men starts the job of cutting a new roadway. When the roadbed is graded, forms will be put in place and concrete poured.

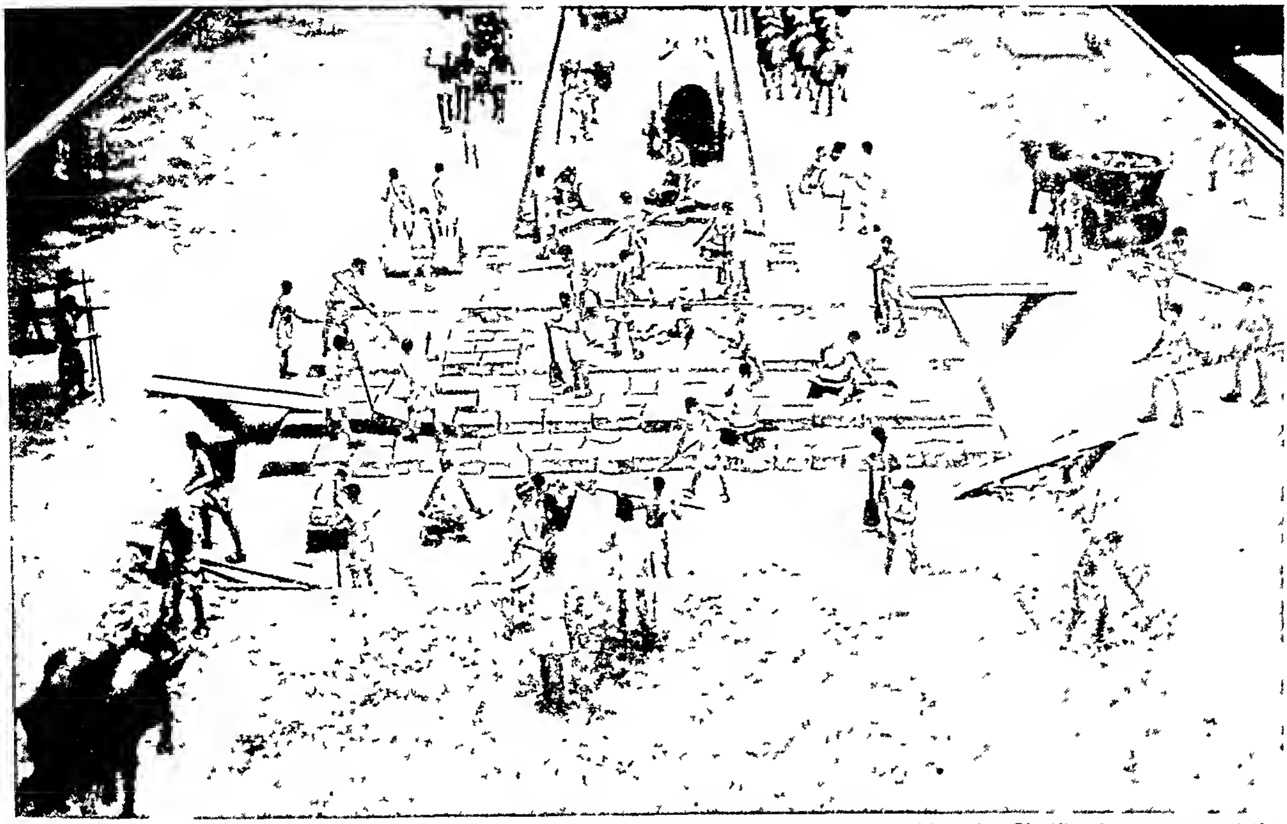


A first layer of concrete has been placed and a steel mesh for reinforcement is being put down. When the mesh is in place, a second paving machine will add more concrete.



This is called a "finishing and floating" operation. The surface of the top layer of concrete has been smoothed, and the men are checking the bituminous-filled expansion joints.

HOW ONE OF THE ROADS THAT LED TO ROME WAS BUILT



This model shows how the Appian Way was built. The roadbed was first covered with sand or mortar. Two layers of flat stones were then put down. A layer of mortar followed, which was filled with small, broken stones. Several more layers of mortar were then poured, each layer being tamped and rolled. Into this mortar were bedded the flintlike lava stones of the wearing surface, their joints fitted so closely together as to be scarcely visible. It would cost more than $500,000 a mile to reproduce the four-foot-thick, hand-built Roman road today. Modern roads cost about $100,000 a mile.

were completed in the period between the first and second World Wars.

In 1944 the federal government passed legislation for broad-scale highway improvement throughout the country, and the legislation was renewed in 1948 and 1949. This program of improvement was to continue for many years.

United States Numbered Highway System

Important main routes of the country are marked with shield-shaped route markers bearing the initials U S and a route number, such as U S 1 or U S 40. Roads so marked are parts of the United States Numbered Highway System. The most important of these make up the interstate system. State routes are also marked. The state markers sometimes take the form of a map of the state, or the marker is in the shape of some symbol associated with the state.

The east-west roads in the United States Numbered Highway System are known by even numbers and the north-south ones by odd numbers. Numbers under 100 indicate main highways, and, with some exceptions, three-digit numbered routes are alternate or feeder routes. The United States Route Numbering Commission makes changes or additions in this system to aid the flow of interstate traffic.

The Lincoln Highway was the first to be marked from coast to coast. Today the original Lincoln Highway is made up of U S 1 between New York City and Philadelphia, U S 30 between Philadelphia and a point near Salt Lake City, and U S 50 from Salt Lake City to San Francisco.

Before roads were numbered road guides were published by private commercial companies and automobile clubs. Private companies also put up road signs that could only be understood by drivers owning each company's guide book.

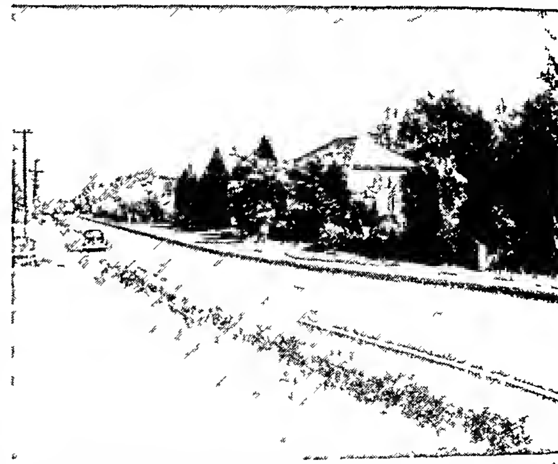
To aid motorists traveling in foreign countries a world-wide system of road signs has been tested. There are now two systems. One uses word explanations and the other symbols. Experiments indicate that symbols are easier to understand, and this system may be adopted generally.

Building the "Alcan" Highway

American sea power, lost at Pearl Harbor, exposed Alaska to attack by Japan. The United States asked Canada if the United States could build a highway through Canada from the United States to Alaska in 1942. Canada consented (*see* World War, Second).

Canada and the United States jointly constructed this road from Dawson Creek, B. C., to Fairbanks, Alaska, through more than 1,500 miles of mountains and swamps in nine hard-driving months. The Alcan Highway, now called the Alaska Highway, cost 115 million dollars. It was used to connect airports and to help build and maintain the wartime "Canol" pipeline system (*see* Canada).

THE ROAD PAST WASHINGTON'S CHURCH—YESTERDAY AND TODAY



The picture at the left shows the highway from Washington, D. C., to Richmond, Va., as it appeared in 1913. At the right is the same highway as it appears today. The building in each picture is Pohick Church, where George Washington attended religious services. This road, which today is U S Highway 1 in Fairfax County, Va., was an early post road.

On April 1, 1946, the United States turned this road over to Canada, and maintained by Canada it remains in peacetime use.

Early Canadian roads were originally built between forts. These roads remain the backbone of the provincial highway system. Widened, straightened, and paved, all are in use today. A trans-Canada highway is scheduled for completion by 1957.

Another great road-building feat of World War II was the construction of the Stilwell Road by the United States Army and Asiatic laborers. The Stilwell Road was built from Ledo in India's Assam province to East Burma, where it followed the old Marco Polo trail to the Burma Road. It was used to carry war supplies from India to China. Originally called the Ledo Road, it was renamed the Stilwell Road in 1945 by Generalissimo Chiang Kai-shek in honor of Maj. Gen. Joseph Stilwell, the United States Army officer who planned it. In March 1946 the United States turned over the road to China, Burma, and India.

Alaska-Pan American Highway System

A major road project of the 20th century has been the construction of the Pan American Highway system to connect the capitals of the republics of South and Central America with each other and with the highway system of the United States. When fully completed, this would enable a motorist to travel from Fairbanks, Alaska, to Puerto Montt, Chile, some 10,000 miles away. Several hundred miles in Central and South America remain unpaved and impassable.

No definite United States route connects the Alaska Highway in Canada with the Pan American Highway in Mexico. One section of the Pan American Highway in Mexico runs south from the United States border at El Paso, Tex., to Mexico City, where it connects with the older and shorter Pan American route running south from Laredo, Tex. The joint highway continues south 857 miles to a dead end at the Guatemala border. Through the major part of the rest of Central America it is paved or gravel surfaced In South America some 13,000 miles of main road and branches are identified with the Pan American Highway system. These roads, with few exceptions, are paved or stone surfaced.

Foreign Roads

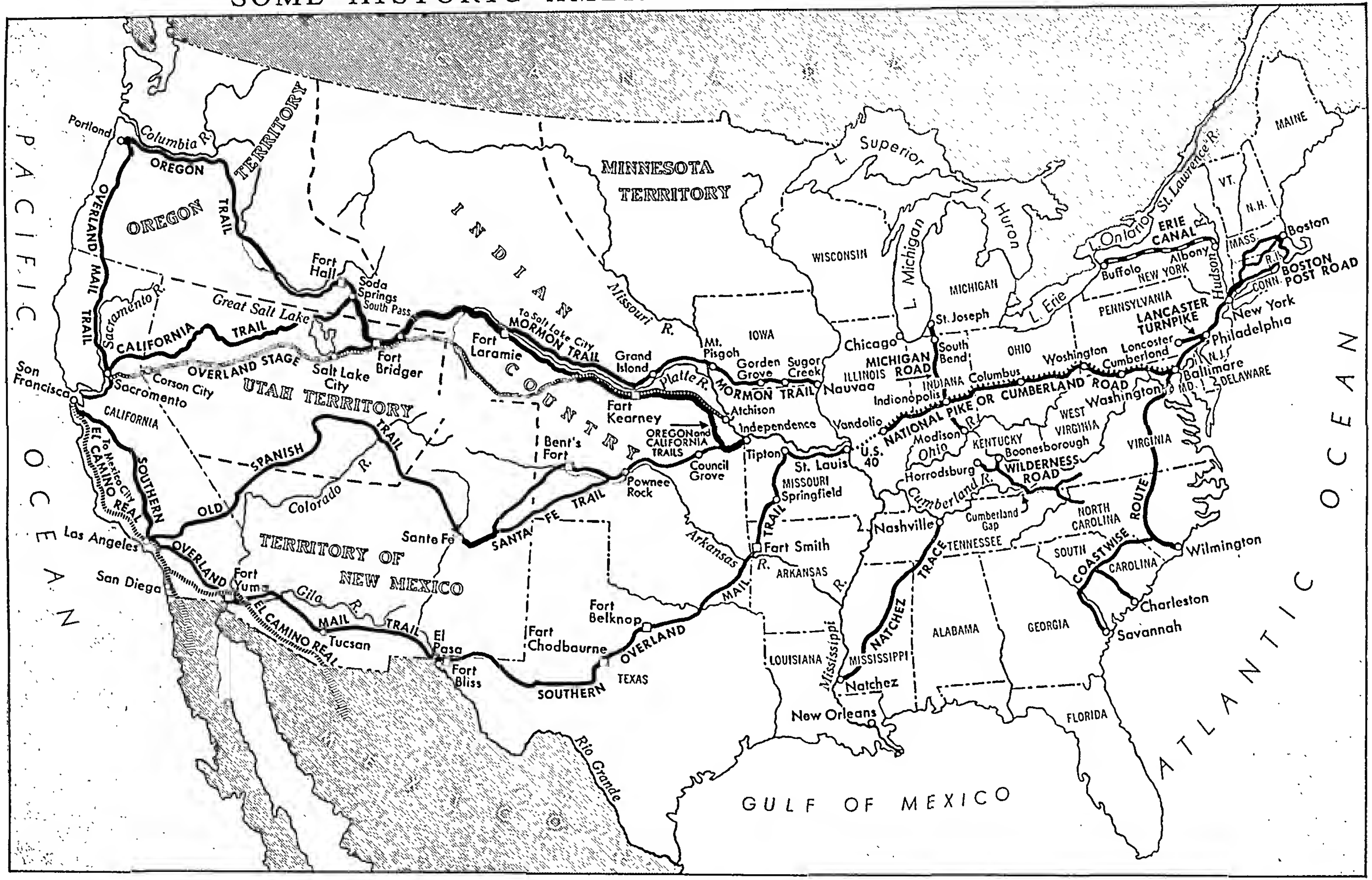
In 1949 the United Nations mapped a plan for an all-European highway system. Under this plan 84 routes would link the major cities of the continent Routes from Helsinki to Marseilles, Paris to Warsaw, and Edinburgh to Rome were mapped and agreed to by the governments involved. There are 23 main routes and 61 feeder routes in this network. This great project even includes a planned tunnel under the English Channel.

Fine modern European roads include those in Belgium, which has as much good road mileage as any area its size. There are excellent automobile

ALONG THE PAN AMERICAN HIGHWAY

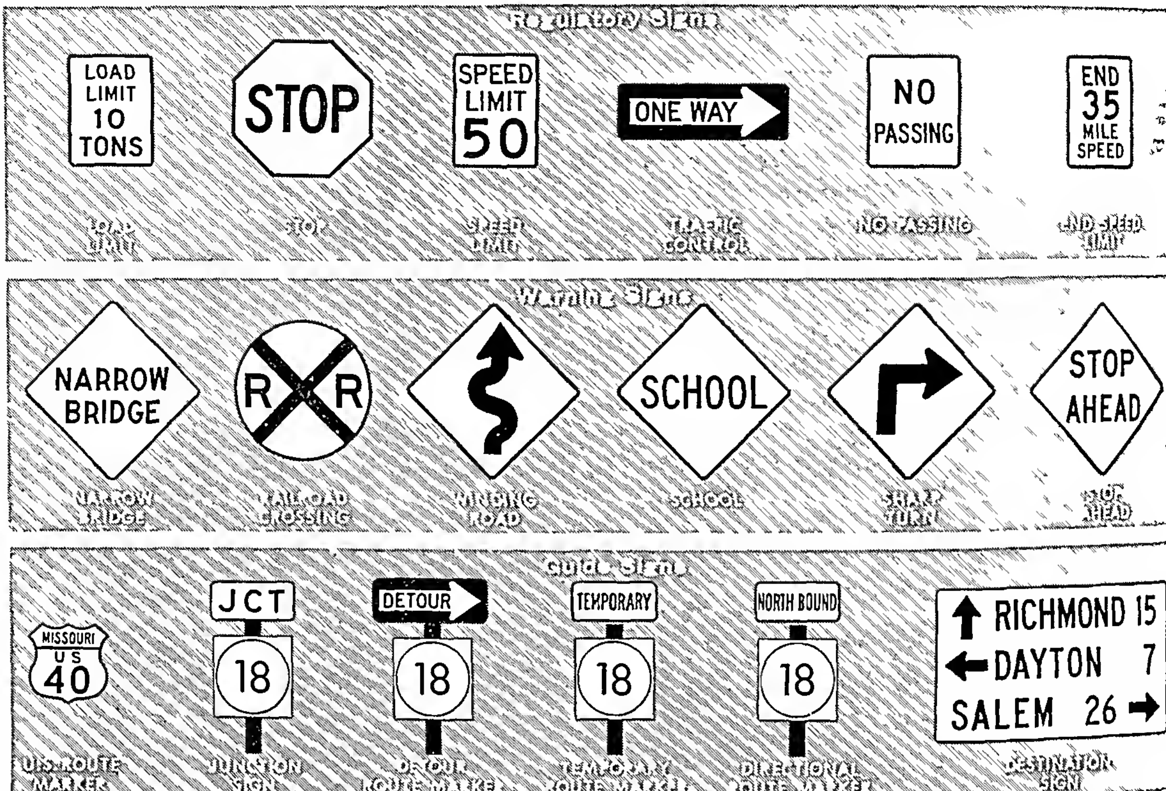
Here a Mexican and his pack animals walk along the edge of the modern Pan American highway. Other highways connect the main cities in Mexico. Good intervillage roads are still needed.

SOME HISTORIC AMERICAN ROADS AND TRAILS



The story of America's growth is written in its roads and streets, many of which began as early trails and traces. This map shows several chapters in this story. Highway US 40, for example, follows the early National Pike. Some of the other modern routes that follow the paths of early trails are mentioned in the text.

SIGNS THAT REGULATE AND SAFEGUARD HIGHWAY TRAFFIC



American traffic signs are in three groups—regulatory, warning, and guide. The stop sign is octagonal in shape; other regulatory signs are rectangular. The railroad crossing sign is round; other warning signs are diamond shaped. Guide signs are rectangular or in special shapes. Warning signs have yellow backgrounds. Guide and regulatory signs, except stop or parking, have white backgrounds. All have black lettering or symbols, except parking signs, which have red or green lettering

roads across the Alps, and Germany constructed express highways before World War II which were chiefly for military purposes.

Early Roads

The ancient Romans were among the first to recognize the importance of military roads. Twenty-nine military roads centered in Rome and extended to all parts of the Roman Empire. At its peak, the Roman road system totaled some 50,000 miles.

The city of Babylon was paved as early as 2000 B.C., and the early Egyptians built a road to assist in the construction of the Great Pyramid. The route over which amber was transported from the Baltic Sea to the Mediterranean Sea was an important early road.

The Persians built a road from the Persian Gulf to the Mediterranean Sea that was similar in construction to modern roads. The Mayas in Yucatán had paved roads, and the Peruvians, Chinese, and Carthaginians were all great early road builders. Like the ancient Romans, the early Incas in Peru, Ecuador, and Bolivia built roads that were mainly for military use.

In many parts of the world, including America, the first roads were started by men following the trails of animals. These were called *traces*. The word *trace* goes back to the Latin word *tractus*, meaning a "track." In pioneer America, however, a *trace* meant a "beaten path" or "trail." Later many of these trails were widened into wagon roads.

How Driving on the Right Originated in America

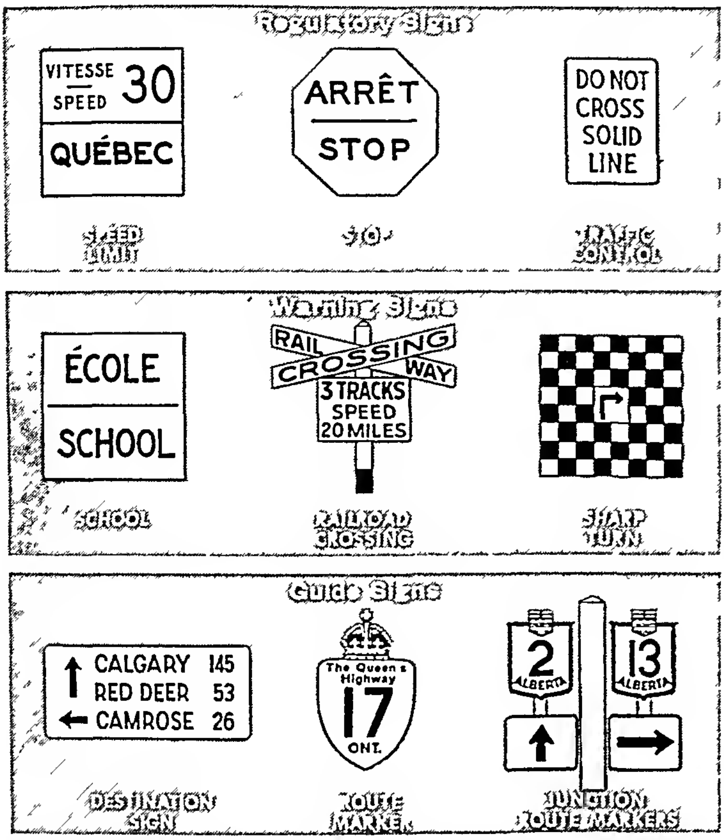
The men who drove the Conestoga wagons along the early roads started the American custom of driving to the right. The Conestoga wagon took its name from the Conestoga Valley in Pennsylvania, where it was first used to carry freight. Americans had at first followed the English custom of driving on the left. The Conestoga wagon driver, however, either walked at the left, sat astride the near left wheelhorse, or rode the *lazyboard*. The lazyboard was a sliding oak board between the left wheels from which the driver could guide the horse and operate the brake. For the driver to have a clear view of the road it was necessary for the wagon to keep to the right. Soon other vehicles adopted the practice.

Some Famous Roads in American History

The roads over which stagecoaches first traveled were called *post roads*, because "posts" for changing horses were maintained at intervals along them. When mail began to be carried over the post roads, places where mail was handled were called *post offices*.

The *Albany-New York Highway*, or *Albany Post Road*, followed the east bank of the Hudson between New York City and Albany. It was blazed in 1667.

SOME CANADIAN TRAFFIC SIGNS



Canadian and American traffic signs are very much alike. In Canada directions are sometimes given in both French and English. Examples of the bilingual sign are shown here. The background is usually yellow or white with black lettering or symbols.

The *Boston Post Road* ran from New York City to Boston. The first postrider traveled this route in 1673.

The *Cumberland Road,* or *National Pike,* was a leading factor in settling the Middle West. It ran from Maryland to Ohio, Indiana, and Illinois. The route was partially surveyed by George Washington. Albert Gallatin urged its construction, and when Ohio became a state in 1803 one twentieth of the public land sale revenue was set aside for the road. Congress authorized its construction in 1806, starting at Cumberland, Md., the western end of the Chesapeake and Ohio canal. The road reached the present site of Wheeling, in what is now West Virginia, in 1818 and Vandalia, Ill., in 1852. It never reached St. Louis, the intended terminal, because public interest shifted to the railroads. Except at the west end beyond Indianapolis, the road had stone bridges and macadam pavement 30 feet wide. The national expenditure on it was about $6,759,000.

The *King's Highway,* or *King's Way,* ran between New York City and Philadelphia, along a track first used in 1677. The first cross-country stagecoach traveled this route in 1756.

The *Little River Turnpike* was the first American turnpike. It was established by Virginia in 1785 on existing roads to run from Alexandria to Bluemount in the Blue Ridge Mountains.

The *Michigan Road* was the first good route between the Ohio River and Lake Michigan. It ran from St. Joseph, Mich., to Madison, Ind. Land for it was ceded by the Potawatomi Indians in 1826. Money from the sale of land along the route was given to Indiana for its construction.

The *Natchez Trace* linked Natchez, Miss., and the middle Tennessee country. It was of great importance in the late 18th and the early 19th centuries. Beginning as a series of Indian trails, it was developed as a post and military road after the signing of treaties with the Chickasaw and Choctaw Indians in 1801. In 1806 Congress appropriated $6,000 to improve and shorten it. Frontiersmen returning home after floating their produce down to New Orleans used it extensively. Never more than a wilderness road, it lost its importance with the coming of the steamboat.

The *Wilderness Road,* which was first called *Boone's Trace,* was a trail, later a road, from the Watauga settlements in northeastern Tennessee and North Carolina to Kentucky through the Cumberland Gap. It followed the Indian "warrior's path" to Manchester and then to a point near Boonesborough. The route was blazed by Daniel Boone in 1775. In 1795 and later the Kentucky legislature provided for a wagon road, ferries, and other improvements, making it one of the best routes across the mountains. Today U S Highway 11, which joins U S 25 near Norris Reservoir in Tennessee, closely follows the Wilderness Road.

The *California Trail* was a route which varied according to the available water supply. One of the most used tracks was from Great Salt Lake along the Humboldt River to the present Reno, Nev., then from Truckee, Calif., across the Sierras and along the Sacramento River to the coast.

El Camino Real (*The King's Highway*) was a track developed informally to connect missions and settlements in California. El Camino Real routes also led from California, New Mexico, and Florida to Mexico City.

The *Overland Stage* was a route first traversed by the fur trader, W. H. Ashley in 1824–25 and popularized when the Overland stages began to use it in 1862 (*see* Express). It followed the South Platte and that river's North Fork through the present Fort Collins, Colo., to Laramie, Wyo. It crossed southern Wyoming to the Green River. Travelers then turned up the Green to the Oregon Trail or went west by the site of Fort Bridger to the California Trail, which they picked up near Great Salt Lake. A part of the Oregon Trail is now U S Highway 30.

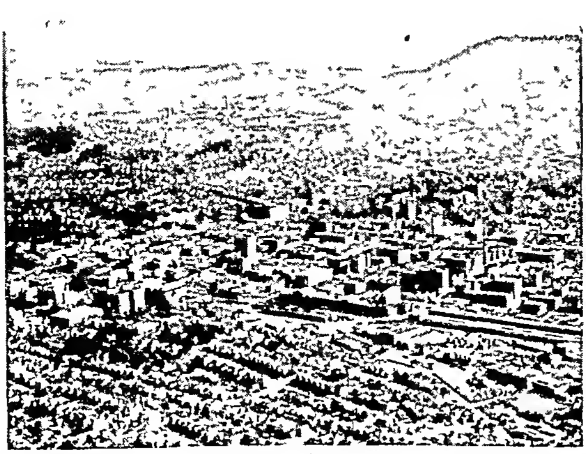
The *Santa Fe Trail* is described in the article Far West. For the route of the *Oregon Trail, see* the article Oregon Trail.

ROANOKE, VA. The most important city of western Virginia did not get its real start until the site, then the village of Big Lick, was selected in 1881 as a railroad junction point and renamed Roanoke (Indian for "shell money"). The city lies at the border of the Piedmont Plateau in a giant bowl formed by the Blue Ridge and the Allegheny mountains. It is at the southern end of the Shenandoah Valley, about 165 miles west of Richmond.

Roanoke is important as a financial, trade, industrial, and transportation center for western Virginia. In its vicinity are coal mines, natural-gas wells, fine quality limestone quarries, and fertile farm lands. The city has the main offices and workshops of one of its two railroads. Important manufactures are rayon yarn, steel bridges, textiles and knitted goods, furniture, and building hardware. Roanoke's industries cluster in the city's center and spread to and beyond the city's limits. A city planning body was organized in 1928.

Within the southern limits of Roanoke, Mill Mountain rises to an altitude of 2,183 feet. Roanoke has made the mountain into a park, with fireplaces, wooded hiking trails, and a unique zoo for children. In 1949 a civic body erected on top of the mountain a neon-lighted, 88-foot star (Roanoke calls itself the Star City of the South). From the top of the mountain can be seen twisting streams, the broad ribbon of the Roanoke River, and a vast panorama of mountain ridges and peaks. About 5 million gallons of water a day flows from Crystal Spring at the mountain's base; until recently this was the city's main source of water. Roanoke has more than 700 acres of parks. Near the city are Roanoke College (in Salem) and Hollins College for women. A Veterans' Administration hospital is also nearby. The Blue Ridge Parkway, the 470-mile-long parked highway and hiking trail that connects Shenandoah and Great Smoky Mountains national parks, half circles the city.

WESTERN VIRGINIA'S LARGEST CITY



Roanoke is picturesquely situated in a bowl formed by the Allegheny and Blue Ridge mountains at the southern end of the Shenandoah Valley. It is western Virginia's most important city.

There was a post office on the Roanoke site as early as 1798. It was called Big Lick because it lay at salt deposits that were frequented by deer and other forest animals. Several early attempts to build the village into a city were unsuccessful. The village welcomed its first railroad in 1852. In 1874 the village was incorporated as the town of Big Lick. In 1884, when its population had increased to more than 5,000, Roanoke was chartered a city. Roanoke has the city-manager form of government. (*See also* Virginia.) Population (1950 census), 91,921.

ROBBIA, DELLA. The Della Robbia family were outstanding artists and craftsmen who lived in Florence, Italy, during the 15th and 16th centuries. They were especially skilled at creating sculptured figures made of glazed terra cotta, enameled in various colors. Their shop in Florence supplied ceramic works to cathedrals, palaces, and guildhalls all over Italy.

Luca della Robbia (1400?–82) was the first and finest of this family of artists. His first training may have been as a goldsmith, but he early turned to marble as his material. In 1431 he created a marble "singing gallery"—a group of singing children carved in low relief—for the cathedral in Florence. His first terra-cotta work was done at the church of Saint Mary in Peretola. Here he used glazed terra cotta in three ways: as a background for marble reliefs, as reliefs against a marble background, and as a mosaic in combination with marble. His glaze consisted of a mixture of tin, litharge, antimony, and other minerals. This was applied to the modeled clay figure which was then fired in a kiln. The glaze was generally milky white, varied with a glowing blue. Other colors were occasionally added to heighten the decoration. Generally regarded as the best of Luca della Robbia's terra cottas are the glazed reliefs of the 'Resurrection' and the 'Ascension' in the Duomo in Florence. He also created notable bronzes—doors, medallions, and altarpieces.

Andrea della Robbia (1435?–1525?) was Luca's nephew and pupil. He entered his uncle's shop as a boy and soon mastered the difficult art. Andrea's figures are larger, brighter, and more detailed than Luca's but they are not considered as fine. Andrea experimented with the use of many colors and with rich ornamentation, especially garlands of fruits and flowers to frame his low reliefs. His best-known work is the decoration of the Loggia dei Innocenti in Florence. Under Andrea's management the Della Robbia shop became a kind of factory where workers and apprentices turned out large quantities of terra cotta work of various kinds, now called Della Robbia ware.

Andrea's two sons Giovanni (1469–1529) and Girolamo (1488–1566) carried on the family tradition. They became even more technically skilled than their granduncle and father, but they tended to use garish colors and overornamentation. Girolamo was also an accomplished architect who spent many years in France. There he helped design several important buildings. (*See also* Pottery and Porcelain.)

ROBERTS OF KANDAHAR, EARL (1832–1914). When Frederick Sleigh Roberts embarked from England for India in 1852, he was a short, well-knit youth of 20 who carried himself proudly in his new uniform of a lieutenant of artillery. The officers of his mess immediately nicknamed him "Little Bobs."

Quiet, keen, cool, brave, and a shrewd observer, he had all the qualities of a good soldier. His men liked him and were willing to follow wherever "Little Bobs" led. Born in India while his father, a British general, was stationed there, he readily learned the Hindustani language spoken by his native soldiers. He trained himself to remain in the saddle for 36 hours at a stretch. He never got lost in the roughest country, or fell sick in the worst pestholes of India, and he was proverbially lucky.

An officer so equipped could always find employment in India. Roberts distinguished himself in the Indian Mutiny of 1857–58, in the Abyssinian expedition of 1867, and in the Afghan war of 1878–80, rising steadily in rank. His most brilliant exploit was performed as major-general in command of the column that marched from Kabul to the relief of Kandahar in August 1880. He covered the distance of 313 miles, through a rough and hostile country, in 22 days and gained a complete victory. For 41 years he served in India, and when he finally left the country in 1893 he was commander-in-chief of the army in India.

The Savior of South Africa

When Lord Roberts (he had been created baron) was in his 68th year, he was sent as commander in chief to South Africa, where the British army was suffering severe reverses in the Boer War of 1899–1902. "Little Bobs is at the helm at last" was the cry of relief from all England. In a few months he brought order out of chaos. He struck at General Cronjé at Kimberley; captured Bloemfontein, capital of the Orange Free State; made the Boers abandon the siege of Ladysmith; divided and demoralized the forces of the enemy; bluffed his way on scant rations into Pretoria; and so turned defeat into victory.

On his return to England in 1901 he became commander-in-chief of the whole British army, and received the title of "Earl of Kandahar, Pretoria, and Waterford." The remainder of his life he devoted to urging the principle of universal military service. He died of pneumonia, in November 1914, while on a tour of inspection of the British forces in France. His life is interestingly told in his autobiography, 'Forty-One Years in India'.

ROBESPIERRE (*rôbs-pē-yêr'*), **MAXIMILIEN** (1758–1794). Robespierre, the most conspicuous leader of the French Revolution during its "Reign of Terror," suffered the fate of many reformers. His virtues for a time won public approval, but his fanatic intolerance brought him to a tragic end.

As a student in Paris and as a lawyer in his native city of Arras, Robespierre was noted for his ability and perseverance. His kindness of heart was shown when he resigned as judge rather than pronounce sentence of death, and later by his attempt to abolish the death penalty. In the Estates-General of 1789 he won popularity by the sincerity and earnestness with which he fought for his revolutionary ideals.

In the Jacobin Club (*see* Jacobins) Robespierre found his greatest opportunity. He became the acknowledged chief of that powerful body, and also a leader of the people of Paris. His reputation for honesty and incorruptibility added to his power. In the "Convention," the third of the French Revolutionary assemblies, Robespierre was leader of the radical party called "the Mountain." He took a decisive part in bringing the king to trial, declaring that Louis XVI "must die that the country may live."

Robespierre was also the best-known member of the Committee of Public Safety (1793–94), which, during the Terror, saved France from conquest by foreign enemies and from internal revolts. But he was not a man of action; he rarely attended the sessions of the Committee, and had almost no part in its routine work. The credit for France's titanic efforts, as well as the blame for the pitiless guillotinings of that time, belongs to men who are not so well known.

In his personal life and in his principles Robespierre was fanatically austere. He was passionately devoted to the effort to establish the principles of Rousseau (*see* Rousseau, Jean-Jacques). As a deist (a believer in God, though not in Christian revelation), he sent to the guillotine Hébert, who had closed the churches and set up a grotesque worship of "the goddess Reason." Danton, to whose superb energy and audacity the triumphs of the Revolution were largely due, was guillotined because he believed that the Terror had accomplished its work and that the time for moderation was at hand (*see* Danton). Then, to check atheism, Robespierre introduced the "Reign of Virtue" and the worship of "the Supreme Being."

Robespierre's Intolerance Brings His Downfall

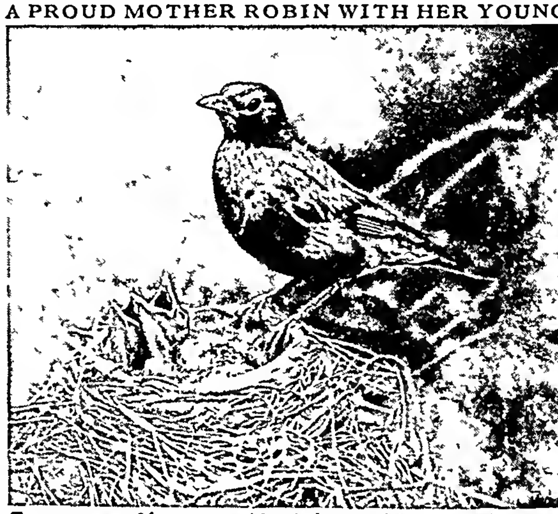
Most of Robespierre's associates on the Committee of Public Safety, however, had little respect for him and little sympathy with his ideas. It was said of him that he had "made Virtue odious by continually prating about it." Many feared that they might be sacrificed, like Danton, to Robespierre's love of power and narrow self-righteousness. On July 27 (the 9th Thermidor in the Revolutionary Calendar), 1794, his enemies forestalled an attempt against themselves by obtaining the arrest of Robespierre, Saint-Just, and others of his intimates. In the confusion which followed an attempted rescue, Robespierre was shot in the jaw. The next day he and 19 of his adherents were guillotined. Danton's words, "Robespierre will follow me; I drag down Robespierre," thus proved true. With his fall, the Terror soon came to an end. (*See also* French Revolution.)

ROBIN. In northern United States and Canada, the robin is the herald of spring. His long-awaited warble at dawn seems to say "cheerily, cheer up, cheerily, cheerily," for winter is over. He has the utmost confidence in the friendliness of man, and carries on all

its affairs within arm's reach of human neighbors. After its sunrise concert it sets briskly to work searching the lawn for worms, its red breast a gay contrast to the green of the grass. It stands still, its black head cocked to one side. Suddenly it darts at the ground, tugs violently, and triumphantly pulls out a worm. It eats quantities of insects as well, but more than half its diet consists of fruits and berries.

Robins build their nests on the horizontal branches of garden and lawn trees, in porch vines, and in eaves. The nest is a bowl of mud, which the mother bird shapes with her breast by turning around and around. It is reinforced with coarse grass, leaves, and roots and lined with grass. A robin lays from four to six eggs of greenish blue, or robin's-egg blue (for picture in color, *see* Egg). There are two or three families a season. The parents defend their young with great courage and will unhesitatingly attack a marauding cat or snake. The old males and young birds assemble at night in roosts, while the mothers remain on the nests with the latest broods. Early in September, after the nesting season is over, they gather in flocks and roam about in search of food until the signal is given to start off for the south. A few hardy individuals winter in the north, taking refuge against storm and cold in deep evergreens and wooded swamps. The southern states know robins chiefly as winter residents. Here their cheery song is seldom heard, and the damage they do to fruits and berries is so great that some farmers obtain licenses to shoot them. The robin is the state bird of Michigan, Wisconsin, and Connecticut. (For a picture story of a family of robins, *see* Nature Study.)

A PROUD MOTHER ROBIN WITH HER YOUNG



Two young robins open wide their mouths, hoping for more food, while the mother bird rests for a moment from the endless task of finding worms to feed them. This is an unusually fine photograph of a female robin and her nest.

Robins are about ten inches long, with round black heads, dark-gray upper parts, rusty-red breasts, yellow bills, and tails tipped with white at the outer corners. (For picture in color, *see* Birds.) The females and young males are paler. Nestlings have the spotted breasts of the thrush family, *Turdidae*, to which robins belong. The birds range from the timber line of Labrador and Alaska to the highlands of Guatemala. There are several subspecies—the eastern, southern, northwestern, and western. Their scientific name is *Turdus migratorius*.

The English robin redbreast (*Erythaca rubecula*) is a different bird, belonging to the family of European warblers. It is about half as large as the American bird, and its breast is orange. It too seeks human companionship and is one of the most beloved birds.

ROBIN HOOD. One of the most romantic of all legendary heroes is the bold outlaw Robin Hood of England. In the days of the Plantagenet kings, the old ballads tell us, Robin Hood with his merry men roamed the green glades of Sherwood Forest near Nottingham in the center of England. There they lived a mirthful life, passing the time in games of archery or bouts of cudgel play, hunting the king's deer, and levying toll on proud churchmen and cruel nobles

No archer ever lived who could "speed a gray goose shaft" from the longbow with greater skill than Robin Hood. And his heart was as true as his aim was sure He was a robber, to be sure, but he robbed only the rich and he shared his spoils with the poor and needy He was fair in war and courteous to his foes He shed no blood if he could help it and he never let harm befall women and children

How did Robin Hood become an outlaw? According to one tale, he had killed one of the king's deer on a wager and then had slain one of the king's foresters who threatened his life A price was therefore set upon Robin Hood's head, and he was forced to flee into the depths of the greenwood

Robin's Band of Merry Men and Their Exploits

Soon there gathered about him other bold men who had been outlawed or deprived of their inheritance, or who hated the hard rule of the barons, or who loved the free life of outdoors better than the settled life of industry. It happened more than once that a man won an honored place in the band by defeating Robin Hood himself in a fair fight. One day, when Robin was about to cross a narrow bridge, a stranger seven feet tall disputed the way. In the bout with quarterstaffs (long, stout sticks) that followed, Robin Hood was worsted and fell into the stream. As soon as he could scramble out of the water and catch his breath, Robin Hood acknowledged the prowess of his adversary and asked him to be one of his men. Thus Little John, so called because of his great size, became Robin Hood's right-hand man. Will Scarlet and Arthur-a-Bland, the tanner, also fought their way into the band and into the leader's affections. Others among the merry men whose names often occur in the ballads were Will Stutely, Much, or Midge, the Miller's son, and the romantic minstrel Alan-a-Dale. Robin Hood's chaplain and confessor was the fat and jovial Friar Tuck.

In the later ballads we hear of Robin's sweetheart Maid Marian. When Robin Hood was outlawed, she dressed as a page and went to seek him in Sherwood

Forest. At last they met; but since both were disguised, neither recognized the other. They fought until Robin, admiring the valor of his foe, invited Marian to become one of his band. Then she recognized his voice.

Robin Hood's greatest enemy was the Sheriff of Nottingham, who sought by force and by guile to bring the outlaw to justice, but was always outwitted. The sheriff even proclaimed a shooting match, feeling sure that Robin Hood would appear to show his skill as an archer. The wily outlaw did appear, but in disguise. He won the prize, a golden arrow, which was handed to him by the sheriff himself. Not until Robin Hood was once more safe in Sherwood Forest did the sheriff learn how he had been tricked.

Although Robin Hood lived on the king's deer, the outlaw "loved no man in the world so much as his king" and would gladly have died for him. According to one tale, King Richard the Lion-Hearted once went in disguise to Sherwood Forest and having tested Robin Hood's loyalty granted him a royal pardon.

FRIAR TUCK OUTWITS ROBIN HOOD

The stout and merry Friar of Fountain Abbey has dropped Robin Hood into the water after being tricked into carrying the outlaw across a stream. Here he stands, laughing at his victim's wrath. As an outcome of this adventure, Friar Tuck joined Robin's band.

A Real Person or a Mythical Character?

Was Robin Hood a real person? It is possible that there is some historical basis for the legends; that they grew up about some actual victim of the ruthless forest laws of old England. Robin Hood is said to have lived from 1160 till 1247. Some stories represent him as a yeoman, others have it that he was of noble birth. According to some accounts, he was created Earl of Huntingdon by Richard the Lion-Hearted. Most of the legends say that Robin Hood died at Kirklees Priory, in Yorkshire, and near the ruins of this priory is a grave supposed to be Robin's. The epitaph (with the spelling modernized) reads:

Here underneath this little stone
Lies Robert, Earl of Huntingdon.
Ne'er archer was as he so good
And people called him Robin Hood.
Such outlaws as he and his men
Will England never see again.

Below is a statement that Robin died in 1247. Some believe that the inscription, which is in 18th-century lettering, is a copy from an earlier and genuine stone, but most scholars doubt this. An argument against the existence of the hero is the fact that he is mentioned by no historian of the time during which he is supposed to have lived. Even if there is some basis of truth in the legends, the details could not all be possible, and the events referred to in the stories could not all have taken place during his lifetime.

More probably, Robin Hood was a mythical character that was first introduced into England in connection with the plays and pageants and morris dances of the May-day celebrations. The earliest record of a "Robin" connected with such festivities is in the rustic plays given at Whitsuntide in France in the 13th century. The hero was called *Robin des Bois* (Robin of the woods). The fact that an old English spelling of *wood* was *whode*, which could easily have become *hode*, might account for the name Robin Hood. At any rate, in the 15th century and later, the May-day celebrations in England were called "Robin Hood's Festivals." Garlands of flowers, a Maypole, morris dances, archery contests, and bonfires were features. Robin Hood was King of May, and Maid Marian was his queen.

Robin Hood's Place in Legend and Literature

Whether Robin Hood was a semi-historical character or only a mythical figure, he represents the ideal of the common people in England in the later Middle Ages, as King Arthur represents the ideal of the upper classes. He stands for liberty and the rights of the people against oppressive laws and the tyranny of the nobles. Many countries have their outlaw heroes, more or less legendary, who defy unjust authority and perform miracles of prowess against the oppressors. Robin Hood thus holds a place with the legendary William Tell of Switzerland, and with Rob Roy of Scotland and Wat Tyler and John Ball, who led the Peasants' Revolt in England in 1381.

The most ancient ballads of Robin Hood have been lost, but between 30 and 40 have been preserved, some of them dating as far back as the 14th century. In addition to these, a connected life of the hero in verse, entitled the 'Little Gest of Robin Hood' (*gest* means a tale of deeds), was compiled from a number of the older ballads and printed about 1500. The best modern version of the legends is Howard Pyle's 'Merry

Adventures of Robin Hood'. From about the end of the 16th century Robin Hood became a popular subject for dramas and operas. Tennyson's drama 'The Foresters' is based on legends of the outlaw, as is also Reginald de Koven's light opera, 'Robin Hood'. Sir Walter Scott introduced Robin Hood into two of his novels—'Ivanhoe' and 'The Talisman'.

ROBINSON, EDWIN ARLINGTON (1869–1935). Although many critics honored him during his lifetime as "the greatest living American poet," Edwin Arlington Robinson was not widely known among his countrymen. This was due partly to the fact that his poetry is too subtle and closely packed with thought to be read easily, and partly to the retiring character of the poet himself.

Robinson was born in the little village of Head Tide, Me., but passed his boyhood in Gardiner, the "Tilbury town" of many of his poems. He entered Harvard in 1891, but had to leave after two years because of his father's illness. He had already published two small volumes of verse, when in 1900 he went to live in New York City. He continued to write poetry while he supported himself by various kinds of work, including that of subway inspector. Through President Theodore Roosevelt, who became interested in his poetry, he got a position in the New York customs house which he held for several years. The rest of his life was devoted entirely to writing. For many years he spent his summers at the MacDowell Colony in Peterboro, N. H., where much of his finest poetry was written. Gradually recognition came to him. He was awarded the gold medal of the American Institute of Arts and Letters in 1929, and three times received the Pulitzer prize.

As a "biographer of souls" Robinson was equally successful in his sketches of New England characters, such as 'Miniver Cheevy'; in presenting men and women of today in the grip of tragic forces, as in 'Cavender's House'; and in portraying the romantic figures of Arthurian legend, as in 'Tristram'. Although he took a fatalistic and somber view of life, he had a kindly humor, with unbounded tolerance and sympathy for those who seemed to have failed. A reviewer once said that to the poet "the world is a prison house." Robinson replied: "The world is not a 'prison house', but a kind of spiritual kindergarten where millions of bewildered infants are trying to spell 'God' with the wrong blocks."

His compressed style enabled Robinson to present a whole life history in a few lines. Many of his poems are long, but he never wastes a word. His verse is sometimes austere to the point of bareness, sometimes rich in music and sensuous beauty. Occasionally it rises to heights of emotional intensity that have scarcely been surpassed. He followed traditional verse forms, but used them in an individual way.

Robinson's poetic works are: 'The Torrent and the Night Before' (1896); 'The Children of the Night' (1897); 'Captain Craig' (1902); 'The Town Down the River' (1910); 'The Man Against the Sky' (1916); 'Merlin' (1917); 'Lancelot' (1920); 'The Three Taverns' (1920); 'Avon's Harvest' (1921); 'Roman Bartholow' (1923); 'The Man Who Died Twice' (1924); 'Dionysus in Doubt' (1925); 'Tristram' (1927); 'Sonnets' (1928); 'Cavender's House' (1929); 'The Glory of the Nightingales' (1930); 'Matthias at the Door' (1931); 'Nicodemus' (1932); 'Talifer' (1933).

ROB ROY (1671–1734). Everyone who has read Sir Walter Scott's novel 'Rob Roy' knows something of the exploits of this celebrated Scottish outlaw. His real name was Robert MacGregor. Because of his red hair people called him "Roy," which is the Gaelic word for red. He was also known by the surname Campbell, his mother's maiden name, which he took because the MacGregor clan had been outlawed by the Scottish Parliament.

When Rob Roy was 22, he became head of the MacGregor clan and inherited large estates. Like other land owners of the Highlands, he engaged in raising cattle for the English market. To protect his herds he kept about him a band of armed followers. He himself was famous as a skilled broad-swordsman. He borrowed money from his neighbor the Duke of Montrose for his cattle business, and because of unfortunate speculations was unable to repay it. The Duke seized his lands and had him declared an outlaw, whereupon Rob Roy, in desperation, collected a band of his clansmen and made war on the Duke, stealing his cattle and his rents as well. Many stories are told of Rob Roy's narrow escapes from the troops that were sent to capture him. In 1722 he gave himself up to the English authorities. After being imprisoned for a time he was pardoned and permitted to return to his home in the Highlands, where he died in 1734.

ROCHAMBEAU (*rō-shäṅ-bō'*), JEAN BAPTISTE DONATIEN DE VIMEUR, COUNT DE (1725–1807). For 33 years before he was sent to America to aid the American colonists in their struggle for independence, Count Rochambeau had served with distinction in the French army. When the treaty of alliance between the French king and the American colonies was signed in 1778, Rochambeau was made lieutenant-general and sent with 6,000 men to the aid of Washington. He rendered valuable services in the final campaign that ended with the surrender of Cornwallis at Yorktown.

When the revolutionary movement in his own country began in 1789, Rochambeau for a time took part on the side of the Revolution. But he soon became disgusted with the excesses of the leaders and resigned his command. During the Reign of Terror he was imprisoned and narrowly escaped the guillotine; but Napoleon restored to him his estates and rank. In 1902 the Republic of France presented to the United States a statue of Rochambeau, which now stands in Lafayette Square in Washington, D. C.

ROCHESTER, N. Y. Waterpower and water transportation did much to make Rochester the third largest city in New York State. The city stands on the Genesee River and the New York State Barge Canal and extends seven miles north to its port on Lake Ontario.

Within the city limits the river falls 261 feet in three cataracts. In 1789 the ample waterpower led Ebenezer Allan to build a sawmill and a gristmill.

Later many mills along the Genesee gave Rochester the name the "Flour City." As milling moved westward, Rochester developed its nurseries and it became the "Flower City." It has also been called the "Kodak City." Today it is a city of many industries.

Rochester specializes in products of highly skilled workmanship. It is the world's largest manufacturer of cameras, photographic supplies, optical goods, check protectors, dental equipment, thermometers, and other recording devices. It ranks high in producing men's clothing and accessories; radios, telephones, and other communication equipment; pharmaceutical, medical, and surgical equipment; office equipment; and chemical, food, dairy, and brewing-process equipment. Rich fruit orchards and truck gardens near the city support a food-canning industry.

Rochester has about 2,000 acres of parks. The largest are Genesee Valley and Durand-Eastman. The city is an education and music center. The University of Rochester, founded in 1850, includes its School of Medicine and Dentistry, Strong Memorial Hospital, and Eastman School of Music. Here also are Rochester Institute of Technology, Nazareth College, St. Bernard's Seminary, and Colgate-Rochester Divinity School. The Civic Music Association and the Rochester Philharmonic and Civic Orchestras present concerts in Eastman Theatre.

Other cultural facilities are Rochester Public Library, Rundel Gallery, Rochester Museum of Arts and Sciences, Memorial Art Gallery, Ward's Natural Science Establishment, and Eastman House, a photographic museum.

Incorporated a village in 1817, Rochester became a city in 1834. It adopted city-manager government in 1928. An electric subway runs in the old Erie Canal bed. Population (1950 census), 332,488.

How Old MOTHER EARTH'S ROCKS *Were* MADE

ROCK. We may think we know all about rocks, but do we? Suppose we try answering some questions. Are rocks heavy? We answer "Yes," but that answer is not always correct. The frothy-looking rock called *pumice* is so light it will float on water. Are rocks hard? We think of granite, which is so hard we can hardly break it with a hammer. But chalk is a rock. Yet it is soft enough to crumble with our fingers.

FACTS ABOUT ROCKS

Weight—A cubic foot of granite weighs about 165 pounds. Other weights are: limestone, 155 lbs.; marble, 170 lbs.; sandstone, 143 lbs.; slate, 183 lbs.

Strength—Granite can support about 19,400 pounds a square inch. Strength of other rocks: limestone, 9,500 lbs.; marble, 12,700 lbs.; sandstone, 9,300 lbs.; slate, 14,000 lbs.

These figures are averages. They will change somewhat with variations in individual specimens of rock.

What Is a Rock?

Suppose we compare a piece of granite with some hard white pebbles from a brook. These pebbles consist of *quartz*. Scientists say that quartz is a *mineral*. They mean that quartz is a definite chemical substance which always contains two elements, silicon and oxygen, in exactly the same proportions.

Small pieces of quartz make sand. And we find grains of quartz in granite. Granite contains minerals called *feldspars*, which form satiny blocks and crystals. Most granite also has flakes of shiny mineral called *mica* and dark needle-shaped crystals of iron minerals. Therefore, we conclude that a rock is any large mass of one or more minerals which forms part of the earth.

We also use the name "rock" for certain hard substances formed from animals and plants. Coal is formed from leaves, stems, and other parts of plants that died ages ago. Many limestones contain shells and "skeletons" of creatures such as oysters and corals, or limy masses built by plants.

Igneous Rocks "Made by Fire"

Geologists tell us that in many places the outer layers of the earth contain molten masses of rock called *magma*. Magma slowly works toward the surface. Sometimes it breaks out, or erupts, as lava (*see* Lava). At other times it stops in underground cracks or spreads out in sheets between older formations. When lava or magma harden, they make rock. Since the rock was once hot, we call it *igneous*, from the Latin word *ignis*, which means "fire."

Most lava contains a great deal of steam. As the hot rock comes to the surface, the steam swells and fills the lava with bubbly holes. These remain when the lava hardens. Pumice, the rock that floats, is a special kind of lava filled with tiny holes. At times steam gathers underground until it explodes and blows the lava into pieces. Some pieces are as big as boulders. Others are mere grains of dust or "ash." When these pieces fall to the ground they gradually form layers of rock.

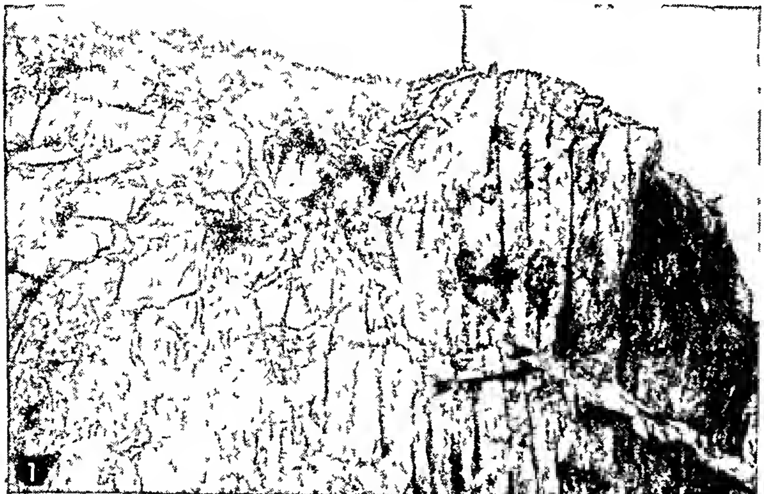
When molten rock cools, it shrinks and cracks. Many cracks in the cooling lava come in threes like parts of a Y. Often they run together. As they work downward through the rock, they divide it into columns that generally have six sides.

When magma hardens and shrinks underground it seldom cracks into columns. It breaks into box-shaped blocks or huge, curved "shells." The minerals in underground magmas also form coarse grains and crystals. In "giant" granite (also called *pegmatite*) the crystals are from one inch to 40 feet long.

Sediment and Sedimentary Rocks

Most rocks at the surface of the earth seem hard enough to last forever. Actually, they are broken down and destroyed bit by bit every day by wind, water, and frost. Large blocks fall from cliffs. Rivers wash pebbles and sand away and carry off tiny particles as silt or mud. Water in the ground dissolves minerals and carries them into streams.

CONTRASTING ROCK FORMATIONS



1. In a remote age a vein of granite was thrust into metamorphic schist. 2. These tilted beds of sandstone show how sedimentary rock usually lies in layers. 3 The thin, wavy bands on the side of the rock formation show that it is gneiss Glaciation molded and scarred the upper surface.

Large blocks stop at the foot of cliffs and form deposits called *talus*. Wind piles dry sand into hills called dunes. Rivers leave mud and sand in lakes and spread them over lowlands during floods. Pebbles, mud, and sand also settle in the sea. So do most of the minerals dissolved by water as it seeps through rocks.

When these materials come to rest they become *sediment*, meaning "something that settles." Large amounts of sediment build up *sedimentary* rocks. Sedimentary rocks also include those formed from remains of living things. Coal is a sedimentary rock. So is limestone formed by sea plants, corals, or shells.

We can tell most sedimentary rocks by two features. First, they are made up of materials that once were a part of still older formations. Second, they lie in layers and beds called *strata*. So we often say that these rocks are stratified.

Most sedimentary rocks are soft and loose when they are deposited. But as layer settles upon layer, the overlying weight squeezes the material close together. Meanwhile, water seeps through the layers. Often it deposits dissolved mineral matter around grains of sediment, cementing them together This turns beds of sand into *sandstone*, mud into *shale*, and limy ooze into *limestone*. Mixtures of mud, sand, and large stones become a rock called *conglomerate*.

Metamorphic Rocks

Some rocks became greatly changed after they were formed. We call such rocks *metamorphic*, from a Greek word meaning "to change form."

Slate is a good example of metamorphic rock. It began as mud, then hardened into shale. Then part of the earth's crust shrank and squeezed the shale until the minerals rearranged themselves in layers, making slate (*see* Slate).

Shrinking and pressure can change rocks even as hard as granite. Often the pressure rearranges some of the minerals in irregular bands. Thus granite becomes a metamorphic rock called *gneiss* (pronounced *nice*).

Much marble was formed like slate and gneiss Its crumpled layers show plainly. Other marble was made when water seeped through deeply buried limestone Water dissolved the limy mineral (calcite) particle by particle from the limestone. Then the water rearranged those particles in little crystalline blocks.

Water also changed many sandstones by depositing quartz around the sand grains. In time each grain became a crystal, locked to other crystals. Thus the sandstone became *quartzite*

Igneous or *contact* metamorphism often occurred where magma was forced into older rocks. The magma squeezed the old rocks, heated it, and sent out steam that dissolved some minerals and deposited others These processes changed the old rocks greatly and sometimes turned them into ores Great copper deposits in Utah and Arizona were made in this way. So were iron ores in Pennsylvania and gold ores in the Black Hills of South Dakota.

The Story of Rocks

Thus we see that rocks tell the story of how they began, how they have changed, and how they came to have their present character. All this is part of the

science of geology. Geology also tells how rocks have been shaped into mountains, valleys, and other forms. The study of rocks themselves is *petrology*, named from the Greek words *petros* (stone) and *logos* (science or discourse). (*See* Geology; Earth; and articles on kinds of rocks under their own names.

Formation of Igneous Rock

IGNEOUS rocks can best be understood by knowing how magma and lava cool into rock. Cooling is governed by the fact that magma contains hot gases as well as rock. The most important gas is steam, for it helps make and keep magma molten.

Geologists believe that magma forms as hot, doughy pockets some 40 miles underground. Then it works outward and upward. At first as it does so, it grows softer and rises more readily. But as it loses steam, it becomes cooler, stiffer, and finally hard.

If this happens quickly the rock is very fine-grained. The cooling minerals in the magma cannot form crystals. But when hardening takes place slowly, the minerals form crystals like those in granite.

Just before magma hardens, some minerals may form large crystals, while other material becomes a fine-grained *groundmass*. A rock of this type is called a *porphyry* (pronounced *pôr'fĭ-rĭ*), from the Greek word for "purple." The ancients gave this name to a dark red porphyry found in Egypt.

Porphyry shows that different minerals separate as they harden. In thick masses of magma, the lightweight minerals tend to rise while heavy ones tend to sink. This process is called *magmatic segregation*.

As molten rock hardens, many different minerals may form, but only a few are common. Two of the commonest in granitic rock are hard, glassy quartz, and softer, more satiny feldspars (*see* Feldspar; Quartz). *Ferromagnesian* minerals are common in nongranitic rock, although some granites have small amounts. They are dark, for they contain iron or magnesium combined with other substances. The five most abundant are:

Hornblende—Green to black; glassy; about as hard as steel. Splits into thin layers.

Pyroxene—Generally green or black. Crystals are short prisms. Not so hard as hornblende.

Biotite or Black Mica—Dark brown to black; splits into thin sheets. About as hard as a finger nail.

Olivene—Yellowish green; almost never forms crystals. About as hard as quartz.

Magnetite—Metallic; dark gray to black; heavy. Is attracted by a magnet.

Igneous rocks generally are divided into four main groups according to graininess or texture. These groups are subdivided according to the dominant minerals, which determine their color. A table with the entry Rock in the Fact-Index shows these groups and subgroups and some important rocks in each.

Sedimentary and Metamorphic Rock

SEDIMENTARY rocks are classified according to the origin of their materials. Those made of broken or decayed bits of older rocks are called *clastic*, from the Greek word *klastos*, or "broken." *Nonclastic* sedimentary rocks are formed by chemical deposition or from remains of plants and animals.

Sedimentary rocks are said to be *unconsolidated* if their material is loose. They are *consolidated*, or *indurated*, if they have been cemented into stone. Sand is unconsolidated; sandstone is consolidated.

Common Clastic Rocks

The coarsest clastic rocks are *conglomerates*. They are made of mud, sand, pebbles, and even boulders. The material is rounded, washed into place by streams or waves, and then more or less cemented. If the large fragments still are rough and angular, we call the rock *breccia*.

Sandstone consists of sand cemented by clay or by minerals deposited from water. The hardest varieties are cemented by quartz; others are cemented by calcite ("lime"), iron compounds, or clay. *Loess* is a soft, gritty rock made of closely packed silt grains deposited by winds or streams. It forms steep cliffs and banks. *Clay* is a soft but compact rock made of very fine particles (*see* Clay). *Shale* is compacted or cemented mud or clay. It may be either soft or hard. *Argillaceous* shale contains sand. *Calcareous* shale is limy, while *bituminous* shale contains tarlike material from ancient organisms. *Oil* shale contains material that yields oil upon distillation.

Nonclastic Sedimentary Rocks

The most abundant nonclastic sedimentary rock is *limestone*. It contains the mineral calcite in various forms, with clay and other impurities. *Chalk* is a very soft limestone made of microscopic shells of foraminifera. *Coquina* is a porous variety formed by cemented shells of small clams. *Dolomite* looks like limestone and forms in similar ways. It is a mixture of calcite and the mineral dolomite, which contains magnesium.

Chert and *flint* are formed in beds or irregular masses from impure quartz. Iron compounds generally stain them yellow, red, or brown. When broken, flint resembles glass but is not so shiny.

Concretions are balls or oddly shaped masses found in softer rocks. They are cemented by quartz, calcite, limonite, or other minerals and often are mistaken for fossils. *Geodes* are hollow structures formed as water deposited minerals in cavities. Most geodes are lined with large crystals of quartz or calcite. A few lack this inner lining.

Processes of Metamorphism

Metamorphic rock can be made from both igneous and sedimentary material, and even from other metamorphic rock. Probably the most common metamorphic rock is gneiss. Regardless of its origin, it looks like granite with the minerals arranged in wavy bands. *Schist* is much finer in texture than gneiss. It consists of flaky minerals arranged in thin, shiny layers that generally are bent or crumpled. A common variety, *mica schist*, is made up of mica, quartz, and small amounts of other minerals.

Metamorphism may also transform different rocks into new ones of the same kind. Pressure and folding may turn either granite or conglomerate into gneiss.

Igneous (contact) metamorphism has turned large deposits of limestone and shale in New England into granite. *Serpentine* is produced when steam from magma changes basalt and some other lavas, as well as schists that once were mud or clay.

Different kinds of metamorphism may also produce the *same* result. Crumpling and pressure, water action, and igneous metamorphism all turn limestone into marble. In contrast, folding and pressure change shale into slate, but igneous metamorphism turns it into *hornfels*, a dark, hard rock that resembles flint or fine-grained basalt.

ROCKEFELLER, JOHN DAVISON (1839–1937). John D. Rockefeller will long be remembered for his fabulous success in business and for his philanthropy. After building the giant Standard Oil Company, he gave away more than a half billion dollars of the fortune his business had won for him.

Rockefeller was born in Richford, N.Y., in 1839. In 1853, the family moved to Strongsville, Ohio, and John entered Central High School in Cleveland. He was graduated at 16 and became a bookkeeper. In 1859, when he was 19 years old, Rockefeller borrowed $1,000 from his father. With this money and his savings of $1,000 he formed a partnership in a wholesale commission house with Maurice B. Clark.

JOHN D. ROCKEFELLER
The Croesus of the Modern World

During the summer of 1859 the first petroleum well was drilled at Titusville, Pa. Rockefeller saw a chance to make money with Samuel Andrews, who had worked out a way to cut the expense of refining crude petroleum. He and Clark joined Andrews in the new firm of Clark and Andrews, petroleum refiners.

During the next ten years the business grew rapidly. In 1870, it was incorporated as the Standard Oil Company of Ohio, with a capital of $1,000,000. The principal investors were John D. and William Rockefeller, Samuel Andrews, Henry M. Flagler, and Stephen V. Harkness. John D. Rockefeller was president and leader in the enterprise.

Rockefeller now saw a chance to gain control of the production, refining, and distribution of petroleum in the United States. At that time the railroads were competing desperately for the business of large companies. To obtain business, they commonly offered to rebate part of the shipping charges paid by large shippers. Rockefeller's group got several railroads to give them 25 to 50 per cent rebates. The railroads also paid Standard Oil part of the shipping charges paid by the company's competitors.

This arrangement quickly froze out the competitors. Within a short time in Cleveland alone, 21 of the 26 refiners sold out to Standard Oil for cash or for Standard Oil stock. When the rebating arrangement became known, public outcry forced the railroads to break their agreement with Standard Oil; but by that time Standard Oil controlled a third of the country's petroleum industry.

Meanwhile, Rockefeller worked to better his shipping and marketing methods. The company hired scientists to improve its products and work out economies. It built storage centers and bought pipe lines for transporting oil. The economies effected by its experts and the improved shipping methods gave Standard Oil a strangle hold upon the petroleum industry.

Now came the development which gave the name "trust" to great American monopolies. The company's Ohio charter did not permit it to own many of the properties which Rockefeller had assembled. So the firm named nine trustees to hold these properties in trust (*see* Monopolies). The arrangement was completed in 1882 as the Standard Oil Trust, with a capital of $70,000,000 (later, $92,000,000). The trust held 39 corporations and controlled three-fourths of the oil business in the United States.

This and other monopolies aroused widespread fear. In 1887 Congress passed the Sherman Anti-Trust Act and followed with other measures. Standard Oil met continued government opposition by dissolving the trust in 1899 and merging the properties as the Standard Oil Company of New Jersey. Finally in 1911 the United States Supreme Court pronounced this arrangement illegal. The various properties were separated and Rockefeller retired.

Meanwhile he had turned from making money to giving it away wisely. He helped open the University of Chicago in 1893 and gave it a total of $34,000,000. He gave generously to other educational institutions and to the Baptist church. Finally he established four great foundations to receive and administer his gifts. He specified the broad purpose of each foundation but left the trustees free to spend the capital funds as well as the income.

The Rockefeller Foundation received an endowment of $182,851,000 "to promote the well-being of mankind throughout the world." The General Education Board was founded in 1902 with $129,209,000 for "promotion of education within the United States of America without distinction of race, sex, or creed." The Rockefeller Institute for Medical Research received $59,931,000 for the study and cure of disease. The Laura Spelman Rockefeller Memorial received $73,985,000 to carry on benevolences in which Rockefeller's wife was interested. In 1929 this fund was merged with the Rockefeller Foundation. Rockefeller died in 1937 at the age of 98. At that time representatives of his family stated that he had given away $530,000,000.

ROCKEFELLER, JOHN D., JR. (born 1874). The only son of John D. Rockefeller, Sr., was born in 1874 in Cleveland, Ohio. He was graduated from Brown University in 1897 and entered his father's business.

Soon he withdrew to supervise the Rockefeller donations. He also gave more than $200,000,000 from his own resources to various causes. Among the larger gifts was $21,000,000 to restore colonial Williamsburg and an equal amount to the International Education Board. Some $11,168,000 went to International Houses at Columbia University, the University of Chicago, the University of California, and in Paris, France. Other recipients include the Northern Baptist Convention, Palisades Interstate Park Commission, Y.M.C.A. and Y.W.C.A., League of Nations Library, and the Metropolitan Museum of Art of New York City. In 1946 he gave the United Nations, for its headquarters, an $8,500,000 site in New York City.

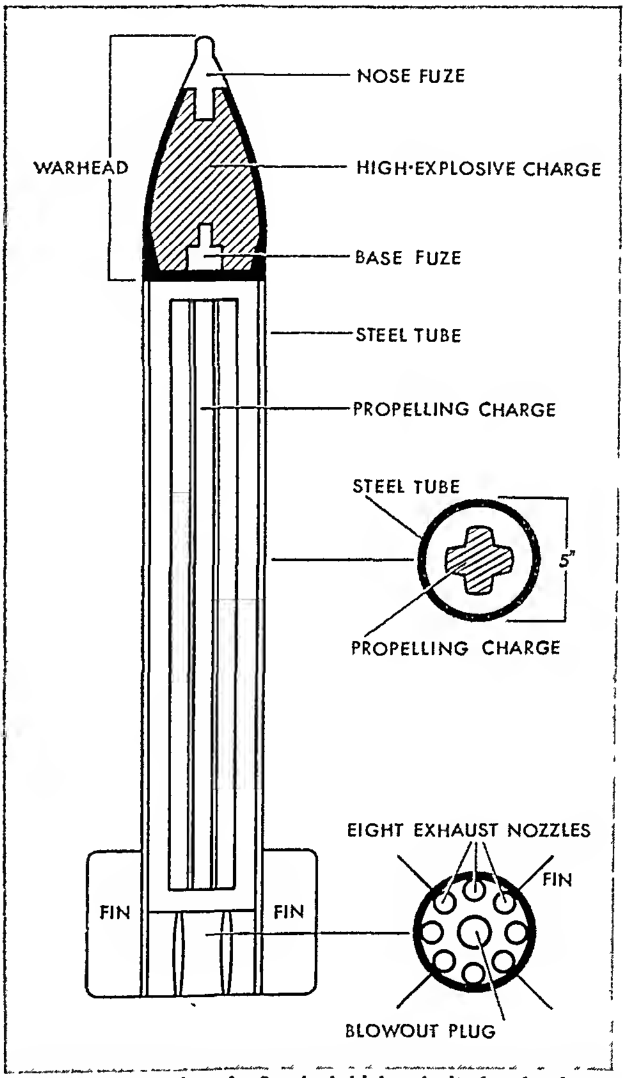
Fiery FORERUNNERS *of* GUIDED MISSILES

ROCKETS. Most of us see rockets only in films and newsreels, since fireworks displays, formerly common on the Fourth of July, have been drastically curbed in most states because of safety and fire hazards (*see* Fireworks). Rockets, however, are not merely display pieces for entertainment. They have become important in a large number of civilian and military applications.

Once more rockets are important and effective weapons of warfare. Large-size rockets of a different type are used to carry scientific research instruments, automatic cameras, and even test animals into the upper atmosphere. Thus we can gather information on the density, pressure, composition, and temperature of the upper air, count the number of cosmic rays striking the earth, check on the many kinds of radiation released by our sun, and take photographs of the ground from heights not yet reached by man (*see* Guided Missiles).

Other types of rockets assist airplanes in becoming airborne—either when they have to carry an overload or have to take off from short runways, such as the flight deck of an aircraft carrier. Still others propel research airplanes at extreme altitudes. The possibility of using rockets as mail carriers is under study, and plans for rocket ships which can leave the atmosphere exist (*see* Space Travel).

A rocket moves in accordance with Newton's third law of motion, which says that for every action there is an equal and opposite reaction (*see* Mechanics). Burning gases are ejected forcibly and violently from an exhaust nozzle of a rocket. The opposed reaction to this "exhaust blast," and not the exhaust blast itself, moves the rocket forward (*see* Jet Propulsion). The greater the speed of the exhaust blast, the greater the reaction against the forward end of the rocket and the greater its speed. Since the exhaust blast need not push against anything at the rear, a rocket can operate even better in empty space, or vacuum, than in the atmosphere where the exhaust blast is slowed down by the air.



This is a cross section of a five-inch high-velocity bombardment rocket of the United States Armed Forces. The rocket is six feet long and weighs 140 pounds. Its range is more than 5,000 yards.

Early War Rockets

The Chinese probably invented the rocket. Their chronicles mention rockets used against the Mongols as early as A.D. 1232. The first references to rockets in Europe are dated 1258. The Arabs knew them too, calling them by a name which when translated means "Chinese arrows." They were occasionally used in land warfare but guns soon proved to be more accurate and more reliable. Only at sea, where the large spread of canvas and the tarred rigging of the ships of that time offered easily inflammable targets, did rockets maintain themselves as weapons for many centuries.

Rockets entered the military picture again at the end of the 18th century when a British force in India was routed by the war rockets of Tippu Sahib, sultan of Mysore. A young English artillery captain, William Congreve, succeeded in building large rockets with incendiary warheads (later they carried bombs as well). These rockets were used in various battles from 1807 to 1825, among them the battle of Leipzig (1813),

which marked the turning point in the Napoleonic wars. Congreve rockets were used in the War of 1812 and inspired the line "And the rocket's red glare, the bombs bursting in air" in 'The Star-Spangled Banner' (for pictures, *see* National Songs; War of 1812).

Congreve rockets had a range of about 3,000 yards but were cumbersome to use because of the long and heavy guiding stick they required. In 1846 an American, William Hale, dispensed with the guiding stick by using three curved vanes in the exhaust nozzle of the rocket, causing it to spin like a rifle bullet. The United States Army used Hale rockets in the war with Mexico. They were later abandoned because artillery was more accurate and had greater range.

Modern War Rockets

World War I was fought almost without rockets (except for signaling) because the propelling charge was still old-fashioned black powder which was weak and unreliable. Such rockets were handmade and could be furnished in limited quantities only. Between World Wars I and II military researchers of several nations succeeded in adapting smokeless powder for rocket propulsion. Smokeless powder not only contains more energy per ounce than black powder but it is of uniform quality, does not deteriorate in storage, and can be shaped easily because it is plastic at one stage of its manufacture.

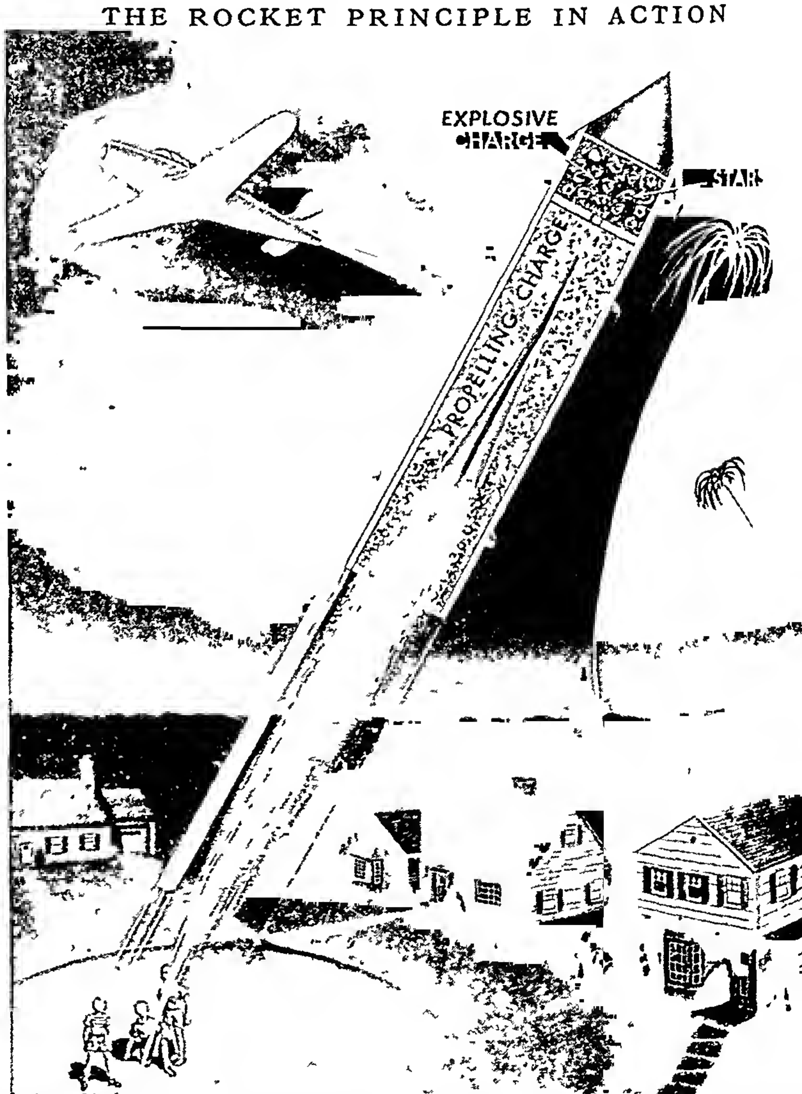
Modern war rockets consist of three main parts. The nose, the so-called warhead, is a steel shell containing high explosive. Then comes the body of the rocket, a simple steel tube, and finally the exhaust nozzle assembly to which the stabilizing fins are attached. There are usually several exhaust nozzles grouped around a center hole which contains a safety plug that blows out when the pressure of the gases becomes too great.

The smokeless powder has the form of a stick (called a "grain") suspended on wires and burning along its whole length for a short time. Maximum burning time is three seconds but may be as little as 1/200 of a second. Large bombardment rockets may hold more than one grain, and each grain may weigh as much as 40 pounds.

Such rockets are fired from airplanes (for picture, *see* World War II), from single tripod launchers on the ground, or from multiple launchers mounted on tanks or trucks (for picture, *see* Artillery). The Navy had rocket ships where launching racks covered the whole deck and were capable of firing several thousand rockets within a few minutes (for picture, *see* Navy). The most common types used in World War II were 4, 5, and $7\frac{1}{2}$ inches in diameter. The famous bazooka fired an antitank rocket 2.38 inches in diameter. A larger bazooka was introduced during the Korean war (for picture, *see* Artillery). Antitank rockets and airborne rockets were and are fired like rifles by aiming at the target. The other rockets were fired like howitzers, in a curving trajectory.

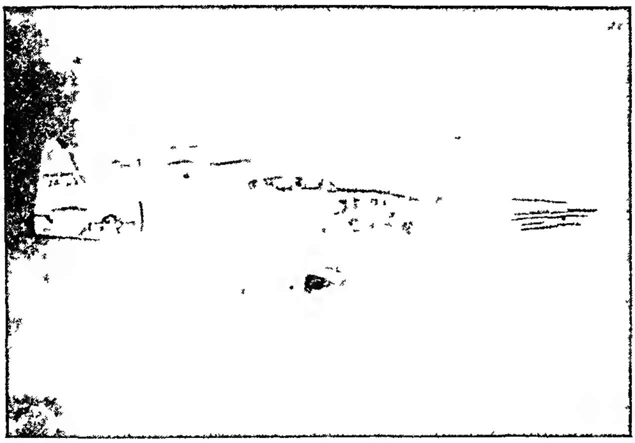
Very large rockets use liquid fuels as described in Guided Missiles. Since the choice of a fuel usually

THE ROCKET PRINCIPLE IN ACTION

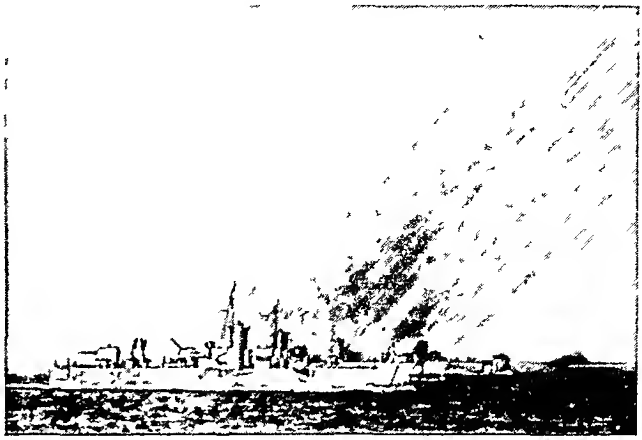


When the fuze of this simple rocket is lighted, the burning gases of the propelling charge rush backward and drive the rocket up. When the charge is exhausted, fire enters the small hole at the top, igniting the explosive which scatters the stars. The stick acts as a stabilizer to prevent tumbling. Jet planes operate on much the same principle

A DEADLY HAIL OF ROCKETS FROM PLANE AND SHIP



An F-94C Starfire is partially hidden by the flash of fire and smoke as 2.75-inch air-to-air rockets are released from its nose.



American LSM(R)'s—Landing Ships, Medium, Rockets—launch five-inch rockets at Japanese-held Okinawa in World War II.

depends on the intended use of the rocket, the main types of rockets and their fuels are listed here. (For bibliography, *see* Space Travel.)

ROCKET	FUEL
Fireworks rockets	Black powder
Signal rockets	Black powder
Bombardment rockets	Smokeless powder
Take-off units	Smokeless powder
Take-off units	Special powder
Take-off units	Liquid fuel
Research rockets	Liquid fuel
Rocket missiles	Liquid fuel
Rocket airplanes	Liquid fuel

ROCKFORD, ILL. Since its founding in 1834, Rockford has turned to industry for support and wealth. Upon settling at the west end of the shallow rock-bottomed ford from which the city takes its name, Germanicus Kent dammed a small tributary of the river to obtain power for operating a sawmill. In 1845 the Rock River was dammed to provide more power for sawmills, gristmills, several farm-tool factories, and a foundry. Today Rockford's more than 400 industries turn out a wide variety of products, including machine tools of many kinds; hardware; auto, tractor, and airplane parts; furniture; knitted goods; textiles; farm machinery and tools; and stoves.

Daniel Haight settled on the east bank of the river in 1835. Stagecoaches traveling between Galena, the lead-mining center in northwestern Illinois, and Chicago forded the river here. In 1839 the two settlements were incorporated as a single town. Rockford is a trade center for the surrounding fertile farm area. Its industrial growth was accelerated by the opening of rail service to Chicago in 1852. The same year the first Swedish immigrants came; more than 30 per cent of the city's present population is of Swedish descent. In 1853 John H. Manny made and sold 150 reapers; the next year he made more than 1,000. In the 40 years between 1860 and 1900 Rockford's industries increased in size and number, and its population grew from 8,117 to 31,051.

Rockford supports Swedish and natural history museums, a symphony orchestra, and an art gallery. It is the seat of a Roman Catholic bishop. Tinker Chalet is a curious, large Swiss cottage built in 1869; its 26 rooms contain period furniture and curios from many parts of the world. Rockford College, for women, was opened in 1849 as Rockford Seminary. Its first student to be awarded a degree was Jane Addams (*see* Addams). Notable among the city's recreational areas is 123-acre Sinissippi Park, which stretches along the river. Camp Grant, just outside the city, was a training center for soldiers in World Wars I and II. Part of the camp has been made into Rockford's airport. Rockford was incorporated a city in 1852. It has the mayor-council form of government. It is Illinois's third largest city (*see* Illinois). Population (1950 census), 92,927; (1952 special census), 105,438.

ROCKY MOUNTAINS. A traveler from the East sees the Rocky Mountains first from the almost level Great Plains. Far to the west stands a steep but broken wall of rock. On a clear day he can see peaks 30 to 80 miles away. Even in summer the highest peaks are white with ice and snow.

These mountains form the eastern rim of the Rockies. They are often called the Front Ranges. West of them lie other ranges, basins, and high valleys. The Rocky Mountain system extends from New Mexico northward into Canada and Alaska. At its widest the system reaches from east-central Wyoming almost to Oregon.

The mountains differ greatly from place to place. Some ranges consist of high, bare ridges and peaks. Others have forests all the way to the top. The Colorado Rockies contain high, wide valleys called "parks." In central Wyoming the system consists of narrow ranges on a broad, desertlike basin. Travelers can go 300 miles without coming near a mountain.

The Colorado Front Ranges are made of red and gray granitic rocks. They rise steeply from the Great Plains, then become a rolling surface with ranges and green forests. Pikes Peak (14,110 feet) and Longs Peak (14,255 feet) tower above their surroundings.

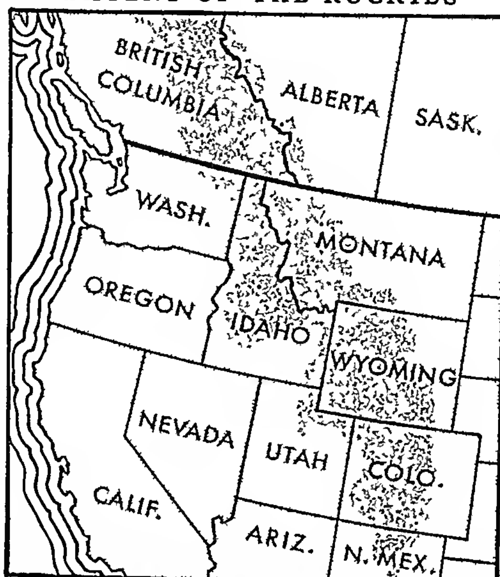
The Bighorns in northern Wyoming are also steep, with rolling uplands and high peaks. West of them

lie the Absarokas, with layer upon layer of brown lava and other volcanic rocks. The Tetons, south of Yellowstone National Park, have a steep eastern face and several sharp peaks. The Grand Teton (13,766 feet) rises more than a mile above a lake at its foot. The Wasatch Range faces westward. It forms a jagged wall that rises 5,000 to 7,700 feet higher than near-by Great Salt Lake. The Lewis Range in Glacier National Park, Montana, is famous for brightly colored rocks and glaciers. Much larger glaciers are found among the Rockies of Canada.

Rain, snow, and melting ice of the Rockies feed many important rivers. The Arkansas River flows through a famous canyon called the Royal Gorge, in the Front Ranges of Colorado. The Yellowstone also has a famous canyon. The Green River in Utah has beautiful canyons but not many travelers see them. The Rio Grande, Colorado, Missouri, Snake, and Columbia rivers also rise among the Rockies. So do the Fraser, Skeena, and Athabasca rivers of Canada.

Yellowstone Lake (7,440 feet) is the highest large lake in North America. Flathead Lake (2,940 feet) in Montana is one of the most beautiful. The Kootenay, Arrow, and Okanogan lakes fill long, narrow valleys in the Rockies of southern Canada.

EXTENT OF THE ROCKIES



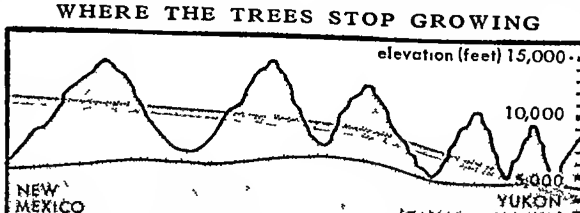
The colored shading shows the area covered by these high western ranges in seven states of the United States, and the southern part of the Canadian ranges.

Climate and Plant Life

Along the lower slopes of the Rockies, the climate ranges from the warmth of New Mexico to the short, cool summers and long, cold winters of northern Canada. Mountain valleys in Colorado are almost as warm as the near-by plains. In Montana, light snows and cold rains come in late August or early September. But cool or cold climate can be found anywhere by going up a mountain to higher altitudes. On the slopes, the climate is like that of Hudson Bay in Canada. On peaks and high ridges, the climate is like that of the frozen country near the Arctic Ocean.

Many ranges are high enough to make the air cold as it blows across them. Moisture in the air condenses and falls as rain or snow. Since most winds in the Rockies come from the west, rainfall and snowfall are heaviest on western slopes. Eastern slopes often are dry and bare. So are many valleys that lie east of high ranges. But many eastward slopes and valleys receive water from snow and ice that melt on high ridges and peaks.

WHERE THE TREES STOP GROWING



Above the colored line, called the *timber line*, no trees will grow. Note how the line slopes down from an altitude of about 12,000 feet in New Mexico to 5,000 feet in the Yukon region.

Each kind of climate supports suitable plants and animals. In the somewhat dry valleys of the Front Ranges, we find the shrubs, grasses, and flowers of the Great Plains. Drier valleys support sagebrush, rabbit brush, salt bush (also called shadscale), and other semidesert plants. The species change gradually throughout the Rockies from New Mexico in the south to the Canadian valleys in the north.

When slopes and valleys have ample moisture, trees grow up to heights where the temperature is low. The upward limit for trees is called the *timber line*. It ranges from 12,000 feet in northern New Mexico to 5,000 feet near Alaska. Above the timber line we find only shrubs, flowers, and dwarf willows. All plant life stops where ice and snow lie all year. The only growth is a tiny organism called "red snow." It is not classified as either plant or animal.

Animal life changes, just like the plants, with location from south to north, and with height.

Settlements, Industries, and Resources

The first white settlers among the Rocky Mountains came for furs or to mine gold and silver. Many towns and cities have grown from pioneer trading posts and mining camps. Others have developed as ranching and farming centers, as railroad division points, or to serve tourists.

There is wild game among the Rockies but too much trapping has made most fur-bearing animals scarce. Sheep and cattle are raised in valleys and among the mountains. Large numbers graze in national forests. The forests produce lumber but they have been badly damaged by fires. Much of the land is dry, with poor soil; but rich farms have been developed in irrigated valleys. Fruits, alfalfa, sugar beets, and beans are among the most important crops.

The Rocky Mountains contain ores of gold, silver, lead, zinc, copper, iron, and other metals. Butte, Mont., is the greatest copper-mining center in the United States and one of the richest mining centers in the world. Coal is mined in Colorado and Wyoming, as well as in Montana, Idaho, and Alberta, Canada. Many unused deposits exist. The largest oil fields of the Rockies are in Wyoming and Colorado. Wyoming has great deposits of oil shale. They may become important when petroleum grows scarce. Marble and a special kind

of limestone called travertine are quarried for use in building.

Parks, Ranges, and Peaks

National parks in the Rockies of the United States include Glacier (Montana), Yellowstone (Montana-Wyoming), and Rocky Mountain (Colorado). The Great Sand Dunes National Monument is in Colorado. Canada has several national parks in the Canadian Rockies. Banff, Yoho, and Jasper are the most famous.

Some of the great ranges in the United States are:

Idaho-Montana—Bitterroot, Coeur d'Alene, Mission, Salmon River
Wyoming—Teton, Absaroka, Wind River, Big Horn, Laramie, Medicine Bow
Colorado—Front Range, "Park" Mountains, Uinta, San Juan, Sangre de Cristo, Sierra Blanca
Utah—Wasatch
New Mexico—Sangre de Cristo, Sacramento

The highest peak in each of the six Rocky Mountain states is:

Colorado	Mt. Elbert	14,431 ft.
Wyoming	Gannett Peak	13,785 ft.
Utah	Kings Peak	13,498 ft.
New Mexico	Wheeler Peak	13,151 ft.
Montana	Granite Peak	12,850 ft.
Idaho	Borah Peak	12,655 ft.

The highest ranges of the Canadian Rockies, the St. Elias Mountains, lie mostly in the Yukon. The chief peaks in the ranges are:

Mount Logan, 19,850 feet.
Mount St. Elias, 18,008 feet.

How the Rockies Were Made

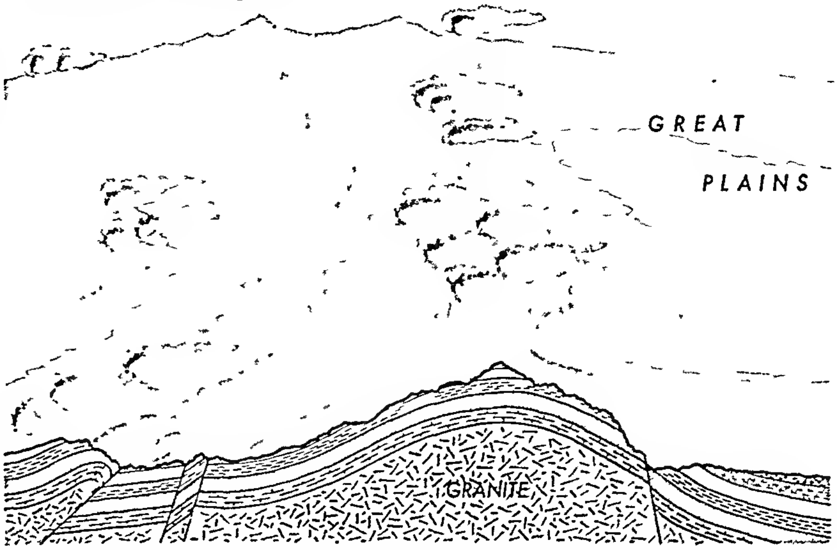
The Rocky Mountains have a fascinating history through the ages. Geologic studies indicate that the oldest rocks were made between one and two billion years ago. Events of these remote times are hard to trace; but geologists can tell us much of what happened in the last billion years.

During this vast span of time, much of the region where the Rockies now stand was covered by shallow seas. At times the earth's crust shrank and crumpled and folded the rocks (*see* Geology). Molten mate-

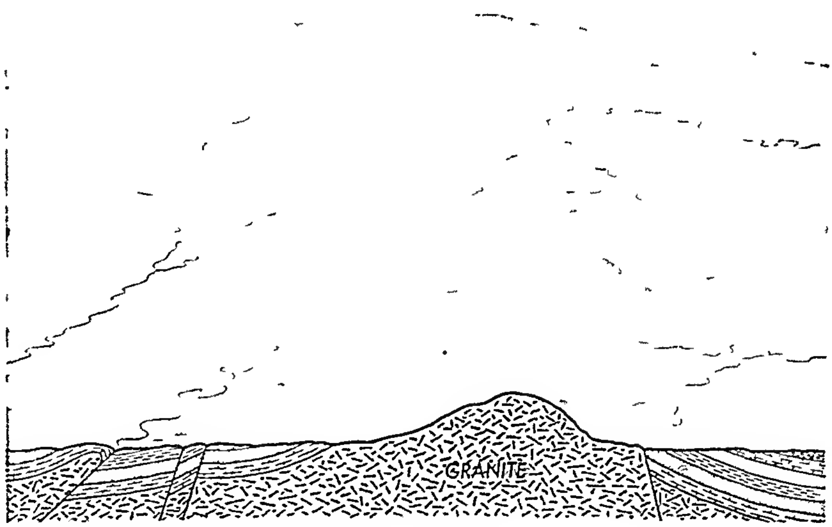
These pictures show the last three stages in forming the Rocky Mountains. The first shows the crumpling, uplift, and volcanic activity which geologists call the Laramide revolution. Next the region was worn down to an almost level peneplain. Then another upheaval set rivers flowing again, and erosion together with the glaciers of the Ice Age carved the present ranges.

CHAPTERS IN THE LIFE STORY OF THE ROCKIES

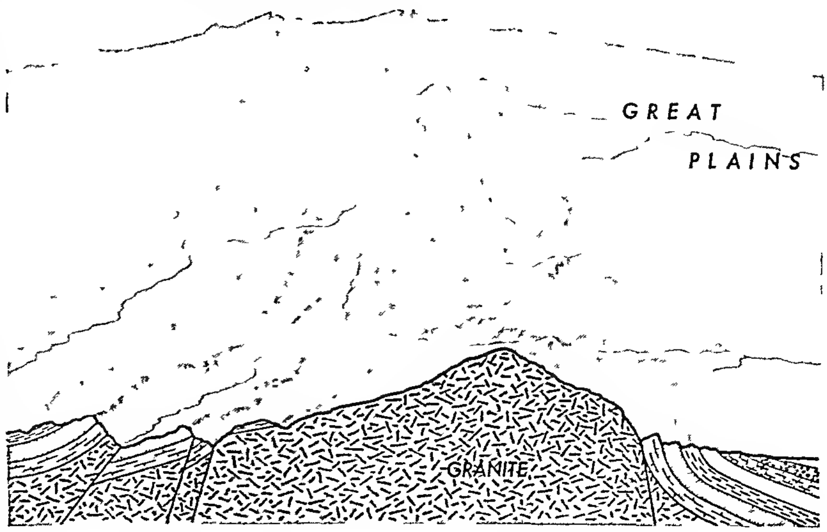
Folding and Uplift



Leveled by Long Erosion



Recent Uplift and Valley Carving



rial (*magma*) came up from the depths into some of the folds. There it cooled and hardened into granite and other crystalline rocks. Meanwhile, rain fell on the uplands, and rivers carried pebbles, sand, and mud into the surrounding seas. They also deposited dissolved limė and dolomite. These materials gradually hardened into conglomerate, sandstone, shale, and other rock (*see* Rock).

At other times the crust sank, deepening the seas and letting water spread over more of the region. Then countless sea creatures left limy deposits which became limestone. All these processes together produced a great mixture of rocks, often enormously thick. The mountains of northern Montana are made from sediment which once measured more than 11 miles from top to bottom.

Geologists date the last sinking at about 115 million years ago. A sea as much as 1,000 miles wide spread from the Arctic Ocean to the Gulf of Mexico, and from eastern Minnesota almost to Oregon. Swamps appeared along the margins and spread gradually into the sea. They supported many strange animals, particularly many kinds of dinosaurs. In many places, remains of swamp plants formed thick beds of coal.

Rise of the Rocky Mountains

Then the land began to arch upward in Colorado and Wyoming. About 60 million years ago, folding became intense. Pressure from the west pushed rocks upward and eastward in a belt that extended from Alaska to central Mexico. Volcanoes erupted, sending out lava and clouds of ashes.

Geologists call this upheaval the *Laramide Revolution*, from the Laramie Range in Wyoming. In the south many of the folds broke and shifted along fractures called *faults*. In the central and northern Rockies, folds were pushed so far that they broke. Then rocks on the westerly side of each break moved over those east of it, forming *thrust faults*, or *overthrusts*. One overthrust in Idaho, called the Bannock, allowed old rocks to move 35 miles over younger ones. Along its edge the overthrust measures 250 miles. The Lewis overthrust east of Glacier National Park, Montana, is equally notable. East of Yellowstone National Park is still another.

The movements of the Laramide Revolution probably lasted several million years. But even while it went on, rain, ice, and streams were wearing away the towering mountains. Rivers carried sediment from them into basins between the mountains and over the Great Plains. At last this erosion reduced the region to an almost level surface, or *peneplain*. Only a few of the highest, most resistant peaks remained as rounded mountains called *monadnocks*.

The Modern Rockies Appear

Just a few million years ago, another movement of the earth's crust heaved up the peneplain into a high plateau. As this happened, streams flowed faster, cutting the plateau into mountains and cutting canyons such as the Royal Gorge through old ranges. Rain, frost, and streams cut away loose sediment from old peaks and let them stand forth again. Tilted beds at the front of the mountains were worn into curved ridges called *hogbacks*. These show very plainly east of the Front Ranges in Colorado.

About a million years ago, the last Ice Age capped the mountains with glaciers. The moving ice cut the ranges into sharp ridges, scoured and deepened valleys, and ground massive mountains into sharp peaks. This erosion produced the most spectacular ranges of the modern Rocky Mountains. Finally most of the ice melted and left the mountains which we see today. (For additional information *see* the entry Rocky Mountains in the FACT-INDEX at the end of this volume.)

RODENTS. The largest order of mammals in point of numbers is that of the gnawing animals or *rodents*. Most of us know the rats, mice, and squirrels of the tribe; but there are many other kinds. About 2,000 species of rodents are distributed in nearly all parts of the world. Between them they can eat almost any kind of food. They live in hot deserts and chill northern forests. They bear young rapidly and would soon fill the entire world if natural enemies did not hold down their numbers.

Rodents may be large or small, fierce or timid. They may live in trees, underground, or even in nests built in the water. But they all have the same kind of jaws and gnawing teeth.

A rodent usually has two chisel-shaped incisor teeth in the front of each jaw. Each tooth has hard enamel in front and softer enamel in back. As the animal gnaws, the soft enamel wears away and the hard front maintains a sharp cutting edge. The teeth grow out as fast as the cutting edge wears away. The lower jaws are hinged to give a sidewise sawing motion as well as cutting up and down.

With these teeth rodents can cut through wood and hard nuts to get food. Rats and mice gnaw their way into houses and barns. Beavers eat the bark of young trees and cut down big ones to make dams.

Most rodents are small; but many are terrible pests despite their size. Rats and mice destroy millions of dollars worth of food and other material every year. Gophers, chipmunks and ground hogs riddle farm fields with their burrows. Many species carry dangerous diseases. But the little squirrellike chinchilla, the muskrat, and the beaver provide valuable fur. The coypu of South America and the West Indies yields nutria fur. The fur of some squirrels is valuable. (*See* Furs table in Fact-Index.) The largest rodent is the capybara of South America. It is about the size of a half-grown pig. The important kinds of rodents are described in separate articles. Rabbits, hares, and pikas, once classified as rodents, have been placed in a separate order, *Lagomorpha*, because of differences in their teeth (*see* Rabbits and Hares).

RODIN (*rô-dăn'*), **FRANÇOIS AUGUSTE** (1840–1917). No artist had a harder struggle than did the great French sculptor, Rodin. He was born in Paris of poor parents and for a time attended his uncle's school in Beauvais. When he was 14, he entered the Petite Ecole, a famous school of decorative art in Paris. He sketched animals in Paris parks at six in the morning

Before Rodin, public taste demanded statues with sleek, polished surfaces. When he died, his genius had popularized a rugged expressive style. Here are some of his masterpieces. 'The Burghers of Calais' (upper left) expresses the anguish of six hostages who in 1347 offered themselves to Edward III of England so that he would spare their city. 'Thought' (upper right) is symbolized by a head rising from a rough block of marble. The 'Adam' and the 'Eve' (lower left) depict the sorrowing parents of mankind. 'The Thinker' (lower right) expresses the struggle of man to use his reason.

and attended drawing school until noon. A pocket lunch gave him a few moments for an art gallery. He worked as a store clerk all afternoon and gave his evenings to drawing.

The program was hard but it gave him courage and independence. He needed both, for he could not follow the current fashion of making sleek, pleasing sculpture. He wanted to express the sternness of life as he knew it. He wanted to express joy and sorrow and pain as he saw them. After studying with the sculptor Antoine Louis Barye, Rodin worked in a studio. When he was 24, he shocked Paris with his statue, 'Man with a Broken Nose'. It was refused for the salon exhibition. Critics cried out that his work was ugly. Rodin answered: "Nothing is ugly that has life. Whatever suggests human emotion, whether of grief or pain, goodness or anger. hate or love, has its individual seal of beauty."

His brave words did not help him. At 37 he was still poor and unknown. Then an unjust charge brought him sudden fame. He had submitted a statue 'The Age of Bronze' for the salon exhibition. But the jury for admissions claimed it was so true to life, he must have molded it in plastic from a living model, instead of creating it by art.

To test the charge, an artist member of the government watched Rodin at work. He declared that Rodin had all the skill needed to create the statue. The government was convinced and bought the statue for exhibition in the Luxembourg Gardens.

The controversy won Rodin friends and more fame than praise might have. He progressed rapidly from then on to world-wide fame and honor, official positions in art societies, and an honorary degree from Oxford University. He also had the satisfaction of seeing the world change to his views of what sculpture should be and what it should accomplish. He married a lifelong friend when she was dying, a short time before his own death.

Masterpieces in Many Moods

Rodin probably reached his peak in his group 'The Burghers of Calais' (for pictures in color, *see* Sculpture). He argued against a pedestal for the group. He wanted them on the pavement in front of the Calais city hall, facing the spot where the English camp had been and where they were to be executed.

His famous 'Thinker' was done as part of a projected 'Portal of Hell,' but he never finished the project. His statues 'John the Baptist', 'Eve', and 'Age of Bronze' are world famous. Several small groups such as 'The Kiss' and 'Eternal Spring' show that he could handle delicate and lovely subjects as well as works in rugged, majestic mood. In 'The Broken Lily', 'Thought', and his monument to Victor Hugo, he got a striking effect by leaving the figure only half cut from the stone.

Famous Rodin Museums

When Rodin was 76 years old, he gave the French government the entire collection of his own works and other art objects he had acquired. They occupy the Hôtel de Biron in Paris as the Musée Rodin. This is the only museum where a sculptor's masterpieces are to be seen as their creator placed them. The French government also preserves his studio at Meudon, near Paris. In 1929 Jules Mastbaum gave a Rodin Museum to the city of Philadelphia, Pa. It contains originals and bronze casts from the Musée Rodin.

ROLAND. Basque mountaineers say that on stormy nights in the Pyrenees, you can hear the ghostly echoes of a horn. The horn was blown many centuries ago by the Frankish hero Roland as he lay dying at Roncesvalles (French *Roncevaux*) in northern Spain.

Roland was a favorite French hero of the Middle Ages. Many stories were told about him and gradually woven together into a great epic poem, the 'Song of Roland'. The poem tells us that the Frankish king Charlemagne was fighting the Saracens in Spain when trouble at home compelled him to return. He left his nephew Roland and a small band to guard the rear of his army by holding the pass at Roncesvalles.

Soon an army of 400,000 Saracens attacked the heroic band. Roland stood in the forefront of the battle, cutting down the bravest and strongest of the enemy with his sword, Durendal. But even the utmost heroism could not prevail against the enemy hordes. Finally Roland's brother-in-arms, Oliver, urged him to summon aid from Charlemagne by sounding his horn, or *oliphant* as it was called.

The horn had been given to Roland by Charlemagne. Of all the knights, only Roland could sound it. On hearing it, birds fell from the trees. The ground shook, chimneys fell from houses, and people cried out with their fingers in their ears.

Only when in deadliest peril would Roland sound it; and he refused to do so now. The battle went on fiercer than before. One by one the Frankish knights fell. Soon only a few remained alive. Then Roland raised his horn. The poem tells what happened next:

> Roland raised to his lips the oliphant,
> Drew a deep breath, and blew with all his force,
> High are the mountains, and from peak to peak
> The sound re-echoed; thirty leagues away
> 'Twas heard by Carle and all his brave compeers.
> Cried the King: "Our men make Battle!"

Charlemagne turned back but it was too late. The little band had been slain and Roland lay dying:

> The Count Roland feels through his limbs the grasp
> Of death, and from his head ev'n to his heart
> A mortal chill descends. Unto a pine
> He hastens, and falls stretched upon the grass.
> Beneath him lies his sword and oliphant,
> And towards the heathen land he turns his head;
> That Carle and all his knightly host may say:
> "The gentle Count a conqueror has died."

So perished the mighty Roland, hero of the Franks, according to the poem. Today we know that the story has some basis in fact. Charlemagne was fighting the Saracens in Spain by 778, when a disturbance on the Rhine forced him to return. He left a rear guard at Roncesvalles and the force was destroyed by the fierce Basques of the region. Among the slain was Count Hruodland, prefect of the Breton March. In time the Frankish name Hruodland became the Roland of the poem.

ROLAND (*rō-län'*), MADAME (1754–1793). "O Liberty, what crimes are committed in thy name," cried this eminent Frenchwoman, and bowed to the clay statue of Liberty standing near the guillotine. Then placing her head on the block, she paid with her life for her opposition to Robespierre, Danton, and their fellow Terrorists of the French Revolution.

As a child in Paris, Marie Jeanne Philipon—as she was then named—was a great reader, devouring all that came her way, and the reading of Plutarch made her a republican. In 1780 she married Jean Marie Roland, a government official who afterwards became a leader of the Girondist party. When the Revolution came, Madame Roland, with her masculine intellect and woman's heart, became the queen of a coterie of young and eloquent enthusiasts in Paris, who professed moderate republican views and opposed the excesses of the more radical party. The frequenters of her drawing-room included not only all the famous and ill-fated leaders of the Gironde, but at first even Robespierre and Danton, leaders of the Jacobins, were of her circle.

When the Girondists fell, because of their protests against the "September massacres" and their attempt to guide the Revolution in moderate courses, her husband escaped from Paris to safety. Madame Roland was arrested and spent months in prison before death closed her tragedy of life; it was during this time that she wrote her unfinished 'Memoirs'. Her character took on a new refinement through suffering; in Carlyle's phrase, "like a white Grecian statue, serenely complete, she shines in that black wreck of things." On Nov. 8, 1793, she was carried to the guillotine along with a trembling printer, whom she asked the executioner to take first in order that her fellow victim might be saved the horror of seeing her head fall. A week later her husband died by his own hand near Rouen, unwilling to live longer in a world of violence and disorder.

ROMANCE. In the Middle Ages the nobles of Europe lived in lonely castles, usually perched in some inaccessible position; and no less lonely was the life of the people within. There were few books to read and fewer who could read them. Travel was hazardous and rarely undertaken except for a pilgrimage or a crusade.

In such a life one can understand that visitors were eagerly welcomed. Peddlers, jugglers, mountebanks of all sorts, were constantly being entertained. Most welcome of all was the minstrel or singer, who was called a *trouvère* in northern France and a *troubadour* in the south. Lord and lady, children and servants, would gather around the fireplace of the great hall to hear the minstrel chant his thrilling tales of love, of war, and of mighty deeds. Through his array of songs ran the spirit of chivalry, the social ideal of the feudal age. (*See* Feudalism; Knighthood.) Chivalry taught knights to defend the church, to make war against the infidel unceasingly, to be courteous, and to keep their word no matter what difficulties arose.

Around these ideals, and around the stories of history and legend which exemplified them, the minstrel built his lays. They were called "romances" because the minstrels used one of the "Romance" languages—that is, languages derived from the old Roman or Latin tongue. (*See* Romance Languages.)

The theme of all these early romances is a quest or search. Whether it is the Holy Grail the knight is seeking, or a lost mistress or mother or father; whether he is seeking forgiveness for a sin or for lack of faith in his lady; or whether he is merely seeking adventure for its own sake—there is always a quest.

The people of the Middle Ages loved to hear of heroes of their own as well as of other lands and times. In France they wanted to hear of Charlemagne, the great king who had conquered barbarian and Saracen (*see* Charlemagne). They liked to hear of his nephew, the legendary Roland, who had died fighting bravely against such great odds (*see* Roland). Other cycles of stories grew up about King Arthur and the Knights of the Round Table, various heroes of the Crusades, and Alexander the Great.

Stories that Grew with Age

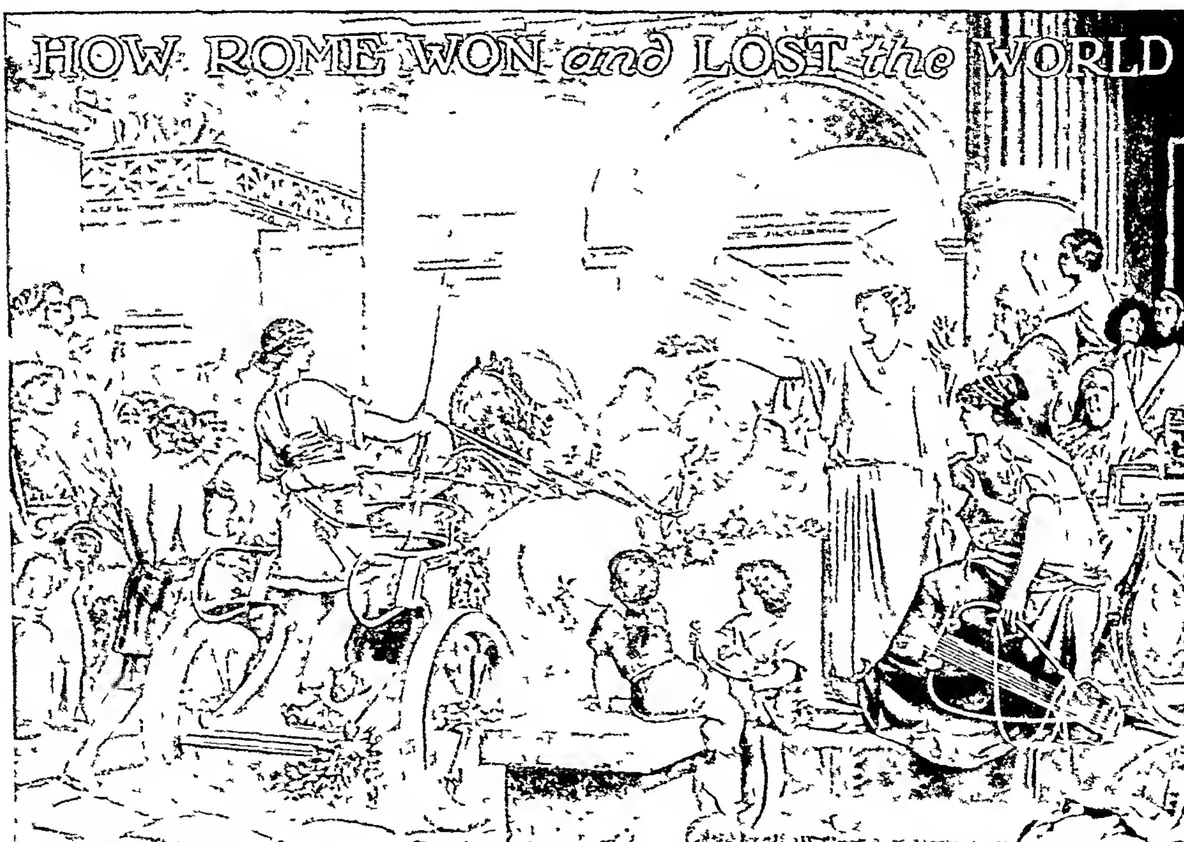
These bright romances grew sometimes to enormous length, as singer after singer embellished the tales handed down by word of mouth and added new episodes in response to the eager demands of his listeners. At first such tales were nearly all in verse, but later prose stories began to appear. An immense body of these romances still exists, written down by various singers and later collected.

To modern taste many of these romances seem fantastic or childish stories, strung loosely together at tiresome length. Yet there is hardly one without its elements of charm and passages of striking beauty. 'Amadis of Gaul' is one of the most interesting. Whether the original of this story was French, Spanish, or Portuguese no one can decide; but it is, as someone has said, "the prose epic of feudalism." The adventures in this 14th century story range from Scotland to Turkey, and giants, enchanters, and magic chambers fill it with amazing incidents. Although Cervantes wrote his 'Don Quixote' especially to ridicule the old romances, he declared that 'Amadis of Gaul' is "the best of all books of this kind that have ever been written."

To English readers the most important group of romances is that dealing with King Arthur and the Knights of the Round Table, and the search for the Holy Grail (*see* Arthur, King; Galahad; Round Table). In prose form the legends of King Arthur are preserved in the famous work of Sir Thomas Malory, 'Morte d'Arthur', and in poetry they have been adapted by Tennyson, Swinburne, and other poets. In fact, the Arthurian legends have served as the richest storehouse of romance from which the English poets have drawn. Perhaps even more important is the fact that these medieval romances contain the germ from which the modern novel has sprung, and that the name has been retained to denote

the type of fiction in which the imagination is given free rein to deal with extraordinary events and characters of transcendent virtues and vices as in the stories of the Middle Ages (*See* Novel.)

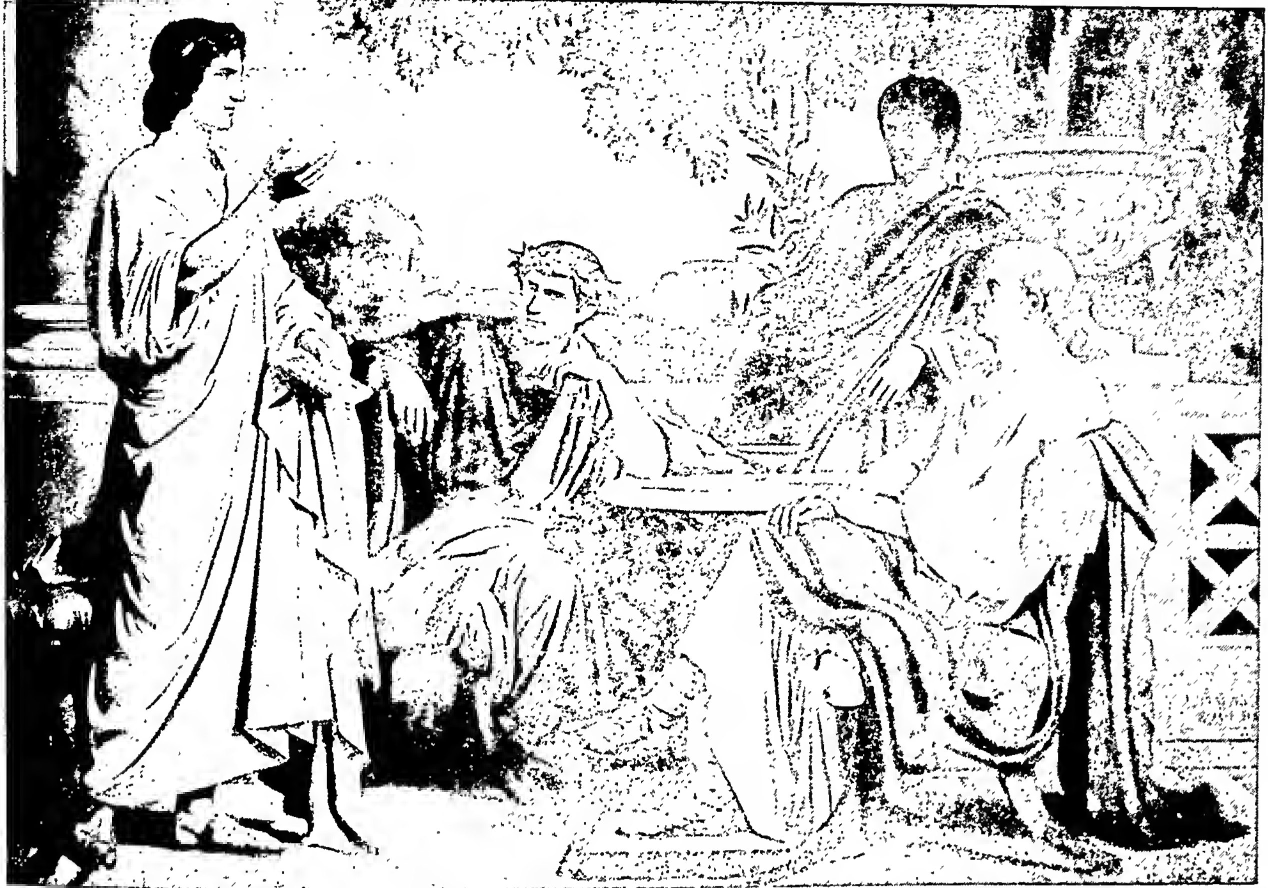
ROMANCE LANGUAGES. The French, Italian, Spanish, and Portuguese languages, different as they are today, are all direct descendants of Latin, the language of the Romans. When Roman colonists spread over Europe as far north as the German forests, they took their language with them. This common language of Europe underwent many curious and interesting changes when learning died out under the barbarism of the Dark Ages. Even in the days of the Roman Empire, the Latin spoken by the people in the various provinces varied considerably, and these differences, influenced by the native tongues of the conquered peoples, by racial character, by geography, and by many other causes, finally transformed the various dialects into languages so different that one who does not know Latin can hardly see any point of resemblance. This group of languages is called the "Romance" group from the fact of their common descent from the Roman tongue. Because they are all derived from Latin, a knowledge of Latin is a great help in learning them. In addition to the four languages mentioned, the Romance group also includes Rumanian and several minor tongues, including a French dialect called Provençal, which was formerly spoken in the south of France and was chiefly used by the troubadors or medieval minstrels.



ROMAN HISTORY. When the curtain rises upon the pageant of Roman history, it discloses the destined mistress of the world a tiny settlement on the Palatine hill, one of the famous seven hills, about 17 miles from the mouth of the Tiber, in central Italy. At this point the river was easily fordable and so merchants from the south had settled here to trade with the powerful, wealthy, and more civilized Etruscans who occupied the lands to the north. The settlement of the Palatine was made by men known as "Latins," who dwelt in the little plain of Latium (the modern Campagna). On the nearby hills were other settlements, the most important of which seems to have been made by Sabines. They, like the Latins, were one of the Italic peoples which had pushed down from the north about 1000 B.C. and conquered the original inhabitants of the peninsula, a dark people of the so-called "Mediterranean" stock. Another branch of the great Indo-European stock had invaded Greece at about the same time. (*See* Etruscans; Races of Mankind.)

The various settlements on the seven hills finally joined to make one city, with common laws, social organization, and religion. At first the Latin chieftains

AT THE CENTER OF ROME'S LITERARY CIRCLE



Vergil is reciting a poem, perhaps one of the Georgics, in which he celebrates the husbandman, or a part of the Aeneid, written to the glory of Rome, while laurel-crowned Horace awaits a chance to read an ode or two. The bald-headed man at the right is Maecenas, a lover of the arts and letters and a generous man of wealth whose name has ever since been a synonym for a patron of poets and painters.

ruled, but before long—perhaps as early as 750 B.C. —the community fell into the hands of Etruscan princes from across the Tiber. Under their enlightened though despotic rule Rome grew steadily in importance and power, and great temples and public works were constructed, notably the huge sewer, the *Cloaca Maxima,* which stands to this day. After about two and a half centuries, however, their cruelty and tyranny caused a revolt which resulted in their expulsion. From that day the name of "king" remained so hateful to the people that even the most despotic of rulers in the later days of the Roman Empire never dared assume the title.

At first the Romans had no written records, and the traditions of their early history became so intermingled with fable that historians have difficulty distinguishing fact from fancy. These legends tell how Romulus ruled for 37 years after he founded the city in 753 B.C. (*see* Romulus); and how he was followed by Numa Pompilius, a wise and pious ruler who, under the guidance of his wife, the nymph Egeria, is said to have taught the Romans the arts of peace and the worship of the gods. Under his successor, Tullus Hostilius, the Romans conquered Alba Longa, the religious center of the Latin people. In this war took place the famous contest between the Horatii and the Curiatii, three brothers from the opposing sides who were selected to decide the struggle by personal combat. The Roman champions won, and not long afterward Alba Longa was destroyed and its people moved to Rome. During the reign of Ancus Martius, the next king, many troublesome Latin cities were conquered and their inhabitants brought to Rome. This ruler is said also to have built Rome's seaport Ostia at the mouth of the Tiber.

Rome Becomes a Republic

Tarquinius Priscus, the first of the Etruscan kings, drained the city, improved the Forum, the commercial and political center of the town, founded a temple to Jupiter, and carried on many wars with the neighboring peoples. Under Servius Tullius, the sixth king, a treaty was made with the Latin cities acknowledging Rome as the head of all Latium. Servius Tullius enlarged the city, the story goes on, and built a wall around all seven hills. The last of the kings, Tarquinius Superbus, was a tyrant and oppressor of the people. He scorned religion, but was induced to buy the famous Sibylline books that thereafter were the chief guidance of Rome in the hour of need (*see* Sibyls). A rebellion against him was led by Junius Brutus, who drove him from the throne (510 B.C.). Rome now became a republic.

Four times Tarquin attempted to regain his power. First, he enlisted the aid of Brutus' two sons. When their treachery was discovered, the stern old father, true to the ancient Roman ideal of duty, condemned them both to death. Next, the men of two Etruscan cities, Veii and Tarquinii, marched on Rome to force Tarquin's restoration. Brutus was slain in the fight, but the Romans won the day. Next, Lars Porsena, an Etruscan prince, seized a high place across the Tiber from Rome. The city was saved only by the heroism of Horatius Cocles and two companions. They held off the whole Etruscan army while the Romans destroyed the bridge. (Macaulay told this famous story stirringly in his 'Lays of Ancient Rome'. A short account is given with the article on Macaulay.)

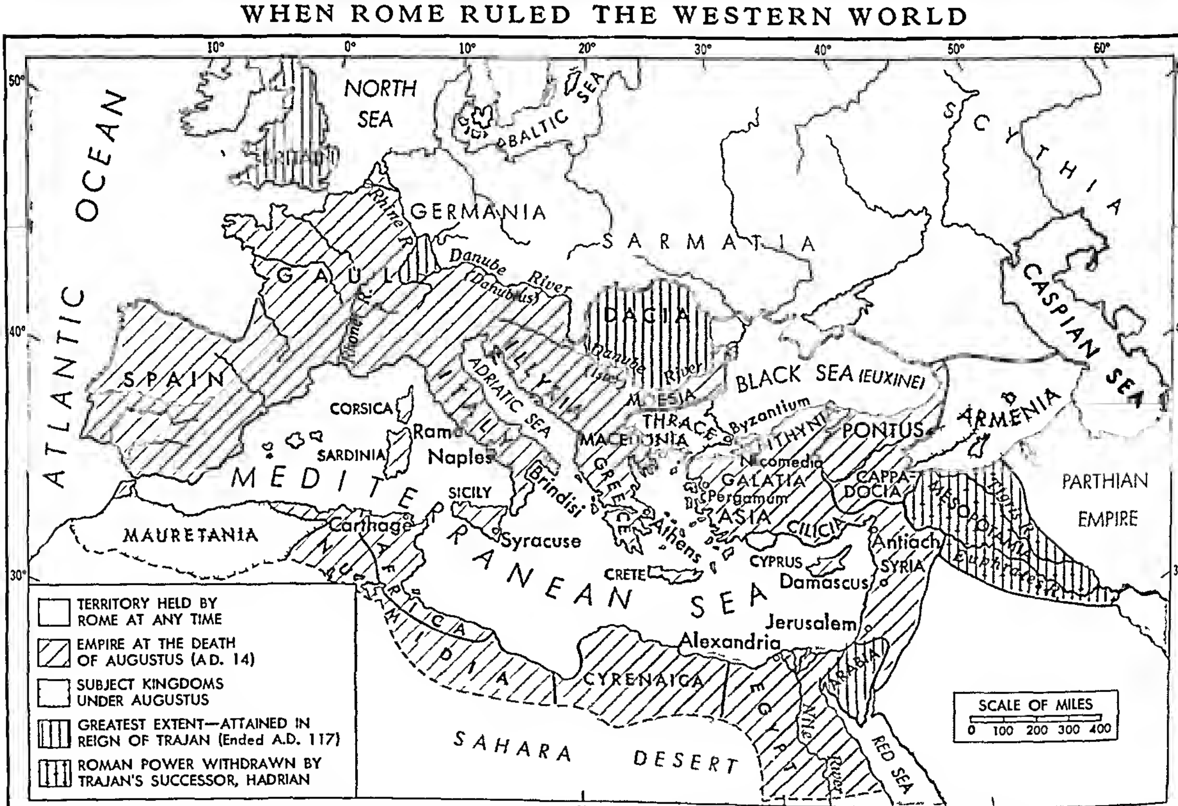
Tarquin finally stirred up his son-in-law, Octavius Mamilius, chief of all the Latins, to lead a revolt. But the Latins were crushed in the famous battle of Lake Regillus. According to legend the Romans were aided in this battle by Castor and Pollux.

The young republic now set out on its long career of almost incessant warfare and conquest. At the time it did not seem destined to rule the civilized world. It was only a tiny city-state, much like the city-states that were flourishing at the same time in Greece. Its area was less than 400 square miles and its population was perhaps 150,000.

The government was in the hands of the wealthy and aristocratic citizens, called the "patricians." They were supposed to be descendants of the three original tribes of Rome. The common citizens were called the "plebs" or "plebeians" (*plē-bē′ yăns*). At first they had little more to do with governing than they had had in former days. But bit by bit they tore down the barrier which separated the two orders. The internal history of the republic for the next three centuries is largely the story of how the plebeians wrested reform after reform from the patricians.

In the early days of the republic the ruling power was divided between two patrician magistrates, elected for one year. These were called *consuls*. They were chosen by an assembly called the *comitia centuriata*. It was made up of divisions apportioned in such a way that votes of the patricians counted for much more than those of the far more numerous plebeians. The Senate, the most important political body, consisted of 300 men chosen by the consuls from the patricians. Thus shut out from office and political power, the plebeians were grievously oppressed by their wealthy fellow citizens. True, they were protected from the worst dangers of arbitrary power by the *lex Valeria* (Valerian law) passed in 509 B.C. This law provided that whenever the life or rights of any citizen were at stake, he could appeal from the

WHEN ROME RULED THE WESTERN WORLD



The Romans called the Mediterranean *mare nostrum*—"our sea." This map shows that they had good reason to do so. The yellow portions show the extent of Rome's rule, from the time Augustus formed the empire, until Hadrian became emperor a little more than 100 years later. It encompassed the Mediterranean and ruled every civilized land in Europe and Africa and extended into western Asia. The only other civilized lands on the earth lay farther east in Asia, commencing with the Parthian Empire. The emperor Trajan extended Roman power into Mesopotamia, but Hadrian considered this unwise and withdrew to the old frontier.

HEROIC FIGURES IN THE HISTORY OF ROME

1. Hadrian, an emperor whose reign was the most splendid era of Roman architecture. 2. Cicero, orator, philosopher, man of letters, statesman. 3. Hannibal, greatest of all Carthaginian generals, and the most formidable foe that ever threatened Rome up to the day of its downfall. 4. Trajan, the soldier-emperor under whom the Roman Empire reached its greatest extent. 5. Julius Caesar, orator, soldier, empire-builder, uncrowned monarch in the last years of the Republic. 6. Augustus, the heir of Caesar and the first emperor in name. 7. Scipio Africanus, great general, victor at Zama over Hannibal.

magistrates to the assembly of the people. But they suffered from unjust debt laws and from unfair distribution of the "public lands"—the territory won by conquest.

When a Whole Nation Went on Strike

To redress their wrongs the plebeians resorted to what might be called a "general strike." In 494 B.C. they marched out of Rome in a body and threatened to make a new city. The "first secession" so terrified the patricians that they agreed to cancel all debts and release those imprisoned for debt. Furthermore the plebeians were granted the right to be represented by new officials, called "tribunes," who should have the right to veto the act of any magistrate which bore unjustly on any citizen.

From this beginning, the plebeians went on to gain other rights. They soon won recognition for an assembly of their own (the *concilium plebis*), and forced the appointment of a commission of ten men (*decemvirs*) to put the laws of the state in writing and have them engraved on 12 tablets of bronze (450 B.C.). They gained the right of intermarrying with the patricians (*lex Canuleia*, 445 B.C.) and obtained admission to the various public offices one

after another. The chief of these, which were established to relieve the consuls of the growing burdens of administration, were those of *quaestors*, or treasurers; *censors*, who kept the lists of the citizens, assessed taxes, and supervised public morals; and *praetors*, or judges. The struggle was long drawn out, and it was not until 367 that it was decided that one of the two consuls should be a plebeian. In 350 the plebeians were admitted to the dictatorship, which was an extraordinary magistracy whereby supreme power at critical times was given to one man (*see* Cincinnatus).

Admission to these offices carried with it admission to the Senate, since vacancies were filled from those who had last been elected to public office. The Roman Senate of the republican period has been called the "most distinguished and important political body which has ever existed in the world." Its members were appointed for life, and executives were bound to submit to it all important measures. In theory it was a purely advisory body, but since its members were ex-magistrates, representing the highest ability and influence of the state, any advice it gave was almost certain to be accepted, for no magistrate would dare challenge such a body unless he was prepared to back up his act by force of arms.

The growing power of the plebs was marked by the gradual rise of a new voting body, the *comitia tributa*, in which one man's vote counted for as much as another's. This developed from the plebeian assembly (*concilium plebis*, which still continued to meet) by allowing patricians also to participate. After the passage of a law (*lex Hortensia*) in 287 B.C. making the acts of the plebeian assembly binding on all the people, these two bodies made most of the laws.

The Struggle between Rich and Poor

Side by side with the struggle for political power went on the economic struggle between rich and poor. The wealthy landowners continued to increase their estates, appropriating the best of the lands and increasing their herds until they monopolized the public pasture. They continued the practice of lending money at ruinous interest to the small proprietors, reducing them to slavery when they could not pay. Moreover, the population of Rome was increasing too fast, and the soil was becoming poorer because of the primitive farming methods. The burden of constant warfare fell most heavily on the plebeians, who had to leave their little farms to fight the state's battles. Gradually, however, reforms were forced through, chief of which were the Licinian laws of 367, which again revised the debt laws, limited holdings to 300 acres, and compelled the large landowners to employ a certain proportion of free laborers.

While these momentous changes were taking place at home, the little city-state had been gradually extending its power. Compelled at first to fight for its very existence against powerful neighbors, Rome gradually fought her way to the leadership of the Italian peoples and so paved the way that was to lead to the conquest of the world.

The most formidable of its early foes had been the Etruscans. With their greater numbers and superior civilization, the Etruscans would probably have reduced Rome to vassalage but for the destruction of their fleet in a war with the Greek city of Syracuse in Italy (474 B.C.), and the constant pressure of the Gauls from the north who swarmed into the Po valley toward the end of the 5th century and laid waste the Etruscan cities of the north. Thus aided, the Romans had finally been able (396 B.C.) to take, after a ten years' siege, the powerful Etruscan stronghold of Veii, eight miles from Rome.

When the Gauls Sacked Rome

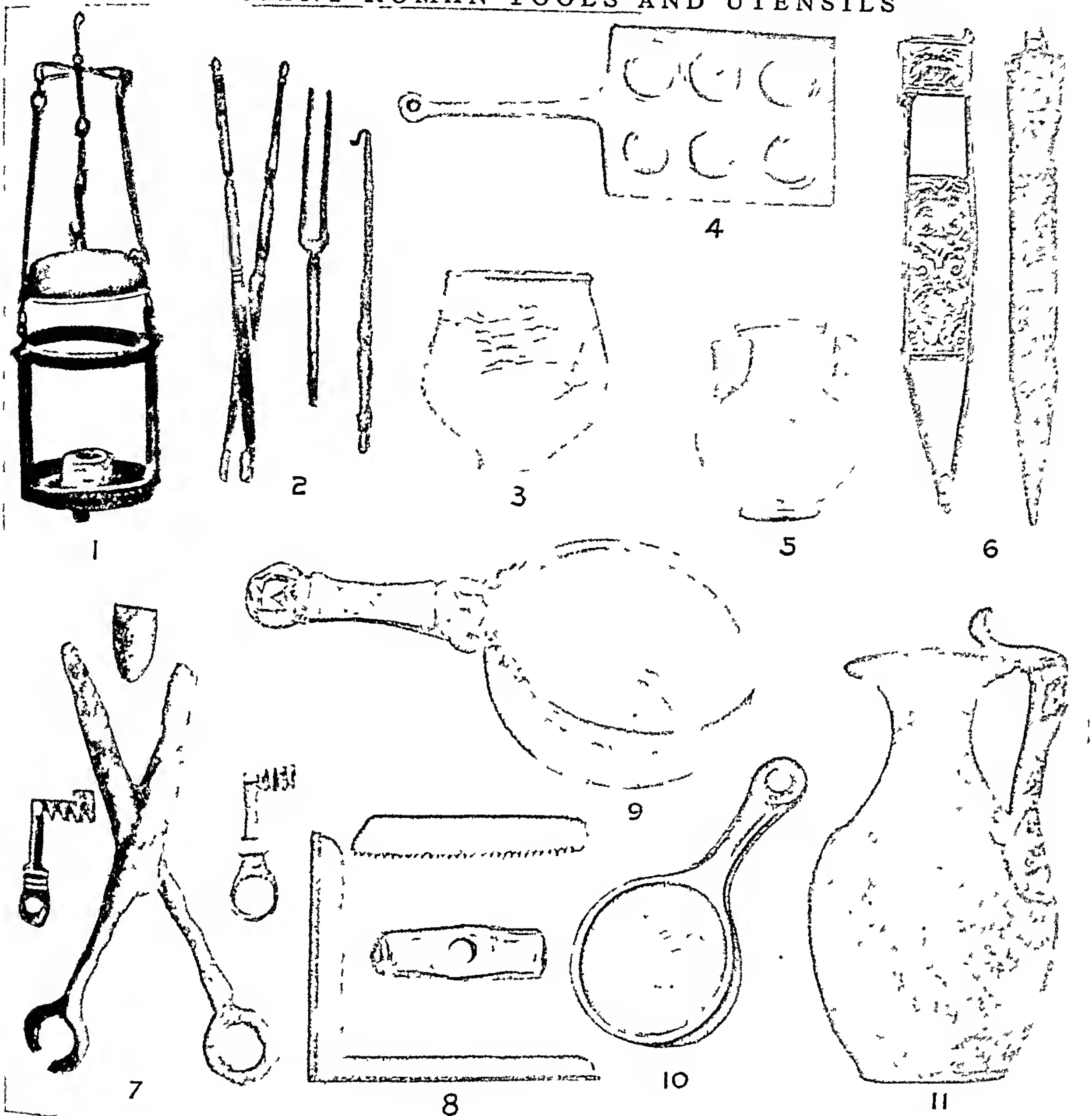
In its conflicts with this foe and with neighboring Italic tribes (chiefly the Aequians and Volscians), Rome was supported by the other Latin cities to the south which were united under the name of the Latin League and had made a treaty with Rome for mutual defense. The victorious progress of Rome received a temporary setback in 390, when wandering Gauls advanced through the heart of Etruria, laying waste the land as they went, and captured and sacked Rome. Legend tells how the garrison on the Capitol Hill was aroused in the nick of time by the cackling of the sacred geese, and repulsed the storming party. After a fruitless siege the Gauls accepted a heavy ransom and returned to the valley of the Po. Though Rome had been burned, the Etruscans had suffered far worse in the invasion and were so weakened that Rome was able to seize their southern possessions and in another century to conquer their whole territory.

Meanwhile the Latin League had become restive under the growing power and arrogance of their ally and attempted to break away from its control. From the two years' war which followed (340–338), Rome emerged victorious, reducing some of the towns to vassalage, giving others full Roman citizenship, and others partial citizenship (the "Latin right").

Another formidable foe in central Italy still remained to be reckoned with, the Samnites, who were also of Italic stock. The first conflict with this warlike people (343–341) had been interrupted by the Latin revolt. The truce then made was broken a few years later (326) and a desperate struggle continued, with interruptions, until the decisive battle of Sentinum (295) made Rome supreme over all central and northern Italy.

Only southern Italy, occupied by a disunited group of Greek city-states, remained independent. Its fate was not long delayed. Alarmed at the spread of Roman power, the Greek cities appealed to Pyrrhus, king of Epirus in Greece. He inflicted two telling defeats on the Roman army and then crossed to Sicily to aid the Greek cities there to throw off the yoke of Carthage. Encouraged by the arrival of a Carthaginian fleet, Rome renewed the struggle, and in 275 repulsed Pyrrhus in the battle of Beneventum (*see* Pyrrhus). One by one the Greek cities were taken, and Rome was mistress of all Italy.

ANCIENT ROMAN TOOLS AND UTENSILS



1. A Roman lantern found near Pompeii. 2. Medical instruments. 3. Pottery vase, showing typical ornaments. 4. Baking pan for small cakes. 5. A glass urn, to hold ashes of the dead. 6. Iron sword and bronze-plated scabbard, found in the Thames near London. 7. Scissors, thimble, and two keys. 8. Saw, hammer-head and T-square. 9. Skillet, found in England. 10. A strainer. 11. A bronze jug.

Nowhere did Roman genius shine with greater brilliancy than in the system which was gradually devised to weld these immense conquests into a contented and unified whole. Instead of treating the conquered cities of Italy as mere subjects, to be exploited for the interests of the conqueror, Rome granted many of them the privileges of Roman citizenship, in full or in part, as she had done with the Latin cities. Most of them were given the status of "allies," with self-government and the right to trade and intermarry in Rome, but not to vote. Furthermore all Italy was dotted with colonies of Roman citizens, most of whom retained their full civic rights. Considerable territory, nearly one-sixth of all Italy, was annexed and distributed among Roman citizens. Thus a common interest in the welfare of Rome was spread throughout the land.

Two centuries of warfare had now made Rome a nation of soldiers. Her only remaining rival in the western Mediterranean was the Phoenician colony of Carthage, which was the chief naval power as Rome was the chief land power. Carthaginian warships made the western Mediterranean a closed sea, and sunk the trading vessel of any other city which dared to bid for a share of the rich commerce of this region. Such a condition was intolerable to the pride of Rome,

and a conflict for Mediterranean supremacy (the Punic Wars) began in 264 B.C., which continued with interruptions until Carthage was finally destroyed in 146. The courage and endurance of Rome were tested to the utmost in this "most wasteful and disastrous series of wars that has ever darkened the history of mankind." The war with Hannibal (the Second Punic War), one historian asserts, was "a trial such as no people has ever gone through before or since, and survived." But the stern devotion to duty, which was the keynote of Roman character, prevailed in the end, and after the battle of Zama (202 B.C.) Carthage was reduced to the status of a vassal state. Fifty years later, with savage vindictiveness, Rome again attacked her prostrate rival and razed the city (Third Punic War). (*See* Carthage; Hannibal.)

Winning World Mastery

Rome was now well launched on her way to world dominion. One conquest led to another. Upper Italy (*Gallia Cisalpina*), Sicily, Spain, Macedonia, Greece, and Asia Minor were subdued and made Roman provinces. Intoxicated with their sudden rise to imperial power, the new generation of statesmen departed from the wise policies of their great predecessors and gave themselves over to ruthless aggression and spoliation. Most of the conquered lands were administered by governors (*proconsuls*), who ruled like oriental despots with the sole aim of amassing in their one year of office wealth for a lifetime. Such enormous taxes were wrung from the subject peoples that they not only defrayed most of the expenses of the Roman state but enriched the greedy tax-farmers (*publicani*), who purchased the privilege of collecting the taxes. Wealth poured into Rome from the four corners of the globe, and the ancient simplicity of Roman life gave way to Asiatic luxury and pomp. Morals were undermined, and vice and corruption flourished. The suddenly enriched officeholders acquired estates and bought up the little farms of the peasants. The peasants were poor and could not compete with the hordes of slaves who worked the great plantations. The streets of the capital were flooded with a poverty-stricken rabble—ruined farmers, discharged soldiers, and idlers from all Italy—who lived on state and private charity as well as on bribes that were bestowed by office seekers.

Between the aristocracy of birth and wealth and the vast moneyless mob there was bitter hostility. War of class against class was bound to come. A few patriotic statesmen tried to avert the dreadful climax, but in vain. The Gracchi brothers, grandsons of the great Scipio Africanus who defeated Hannibal at Zama, came forward as champions of the people and proposed laws to redistribute the public lands and to limit the powers of the corrupt and selfish Senate. Both fell victims to the hatred of their foes, Tiberius in 133 B.C., and Gaius 12 years later.

The death of Tiberius marked the beginning of a century of revolution and civil war that ended in the downfall of the Roman Republic and the establishment of the Empire. Henceforward armies, not votes, were to determine the course of events. First of the popular military chiefs was Marius, who had become a national hero by capturing Jugurtha, leader of an insurrection in Africa, and almost destroying (102–101 B.C.) a horde of German barbarians (the Cimbri and Teutones) who had disastrously defeated four Roman armies one after another. In the year 90 the Italian allies, who had long in vain demanded full Roman citizenship, rose in revolt (the Social War). The struggle lasted two years and ended in the bestowal of the rights demanded.

Rivalry between Marius and Sulla, an adherent of the senatorial party, for command in a war against Mithradates in Asia Minor led Sulla to march with his troops on Rome. For the first time Rome was invaded by a Roman army. As soon as Sulla and his legions were safely out of the way in Asia, Marius in turn seized Rome with his army and massacred many of the senatorial leaders. On his victorious return in 82, Sulla took a fearful revenge, slaughtering more than 5,000 of the people's leaders and confiscating their goods. As "perpetual dictator" (81–79) he passed laws transferring supreme power from the people to the Senate, but in vain; the aristocrats were too corrupt and feeble to keep the reins of power.

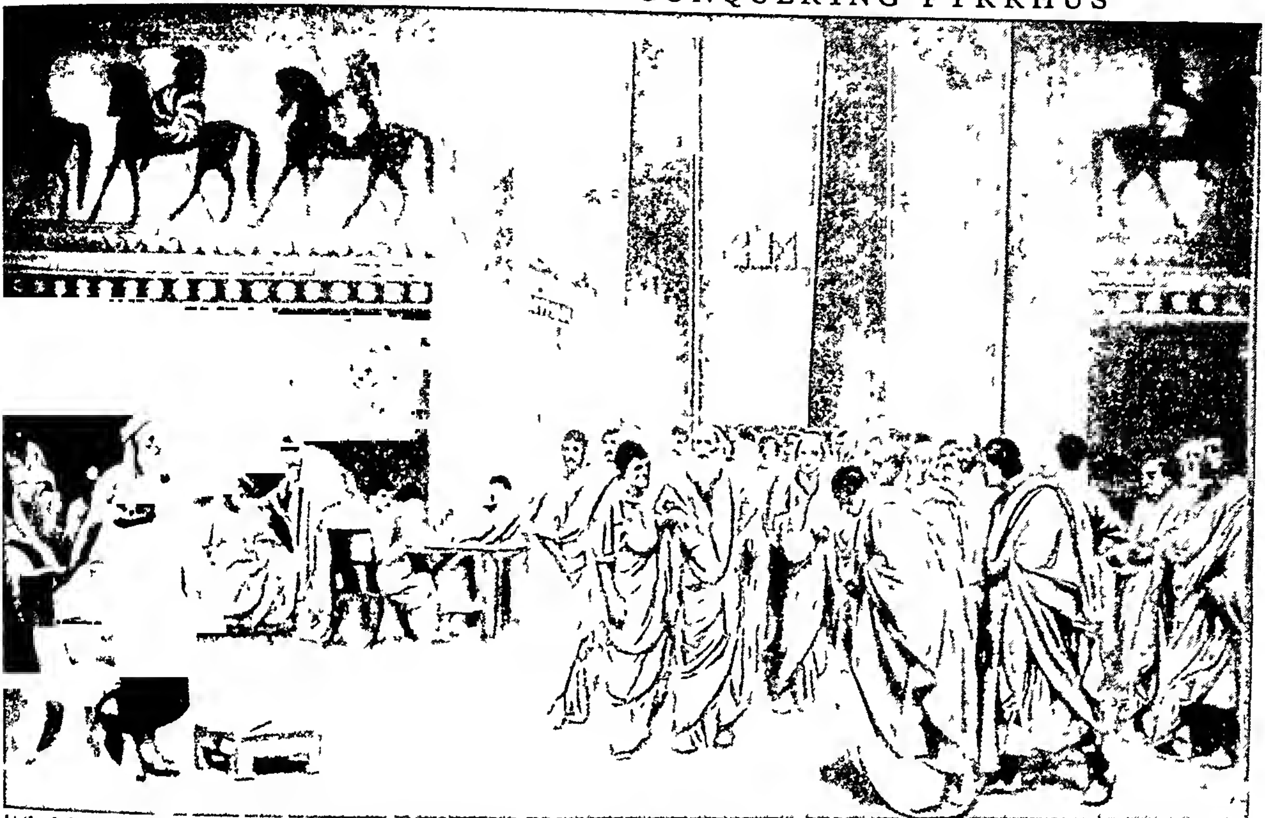
The history of the remaining years of the republic resolves itself into a series of biographies of the great adventurers who now made themselves masters of the town and disrupted state, sometimes joining hands to make their position secure, sometimes waging savage civil warfare (*see* Caesar; Cicero; Pompey).

The only thing that saved the vast edifice of Roman power from crashing to final destruction was the emergence of two statesmen of commanding genius, Caius Julius Caesar and his great-nephew Augustus (Octavian). Scrapping the old republican framework, except in outward form, they remolded the tottering structure into an empire, in which all power was gradually concentrated in the hands of a single ruler, who was backed by the might of the Roman legions. How this change was brought about is told in the articles on Julius Caesar and Augustus. (*See also* Cleopatra.)

Two Centuries of Peace and Prosperity

With the establishment of the empire, the century of civil strife, which had also seen almost constant warfare abroad, was followed by two centuries of profound peace broken only by frontier warfare. At home literature and civilization flourished, and in the provinces responsible men held power. More and more the Mediterranean world assumed the aspect of one great nation. Paved roads led from end to end of Italy, and into what are now France and Germany. Fragments of Roman roads still exist even in far-away Britain, aqueducts and bridges in France, and Roman wells in the Egyptian oases of the Sahara. Roman citizenship was extended to all free men throughout the empire and Roman law was administered in every court. In this period of tranquility, the new religion

THE ROMANS DEFY THE CONQUERING PYRRHUS



At the left is the ambassador sent by Pyrrhus to offer peace to the Senators, because he foresaw that it would be difficult to subdue the Romans, even though they had suffered heavy losses in the recent battle of Heraclea (280 B.C.). At first the Romans were inclined to welcome peace, but the aged Appius Claudius Caecus, the builder of the Appian Way, though so weak that he had to be carried into the Senate chamber, denounced the peace, and stimulated his fellow Senators to reply that Rome never negotiated with an enemy on Roman soil.

founded by Jesus of Nazareth had an opportunity to grow slowly, in spite of repeated waves of persecution, until in the reign of Constantine it became the official faith of the Roman Empire, and ultimately of the whole Western World.

But, though the "Roman peace" (*pax romana*) spread its beneficent aegis over the civilized world, though the remotest lands were ransacked to supply the wealthy citizens with luxuries and delicacies, though art and letters were prized and fostered, the national character was steadily decaying. Gone was the fundamental seriousness (*gravitas*) of attitude which marked all the conduct of Romans of the antique mold. Gone was the old reverence for the family, for the state, and for the gods. Prosperity had brought in the leaven of corruption. In place of a Brutus, offering up his sons on the altar of duty to the state, we find a Nero, murdering his mother and his wife at the prompting of a Poppaea. Selfishness had become the first law of life. The passion for a life of luxurious ease ruled in all classes. The rich amused themselves by giving feasts of unparalleled splendor; the poor had their *panem et circenses*—free bread and free shows Slave labor had degraded the once sturdy peasantry to the status of serfs or beggars. The backbone of the nation, the middle class, had almost disappeared; there were only the very rich and the very poor. After the time of Diocletian the whole empire was put in leading-strings, and under the absolutism of one-man rule society became stagnant, politically, industrially, and mentally. Emperors could build up and maintain a bureaucratic organization of great efficiency, but they could not cure the cankers at the heart of the people.

The events of the imperial history of Rome need not detain us long. Augustus was followed by his stepson Tiberius (14–37 A.D.), a capable but unpopular ruler; then came the mad Caligula (37–41), whose life was ended by his own officers after he had reigned for only four years. Claudius (41–54) was not a strong ruler, but his reign left its mark on the history of the empire, for his generals conquered the southern part of Britain. The infamous Nero (54–68), was the last ruler of the line of Augustus, and his death ended the first century of peace (*see* Nero). For two years there were struggles for the throne between rival military commanders, and civil war was threatened, but with the triumph of Vespasian (69–79) the government became stable. Vespasian's son Domitian, a half-mad tyrant, conquered all Britain. (For table of Roman emperors, *see* Roman History in Fact-Index.)

Domitian was followed by a line of five great emperors—perhaps the wisest and noblest line of rulers the world has ever seen. Nerva's brief reign (96–98) was followed by that of the great conquering emperor Trajan (98–117), under whom the empire reached its

A ROMAN FAMILY DINNER IN THE PERIOD OF DECADENCE

After Rome's conquest of the East, the sturdy simplicity that marked the Roman life of earlier times gave way to Oriental luxury and splendor. The women decked themselves in diamonds, pearls, and rubies from India and robed themselves in silks from China. Peaches, apricots, and other rare delicacies, then appearing for the first time in the Roman world, were brought at immense expense to furnish their tables. And, worst of all, her citizens became degenerate, like the corpulent gourmand at the head of this table.

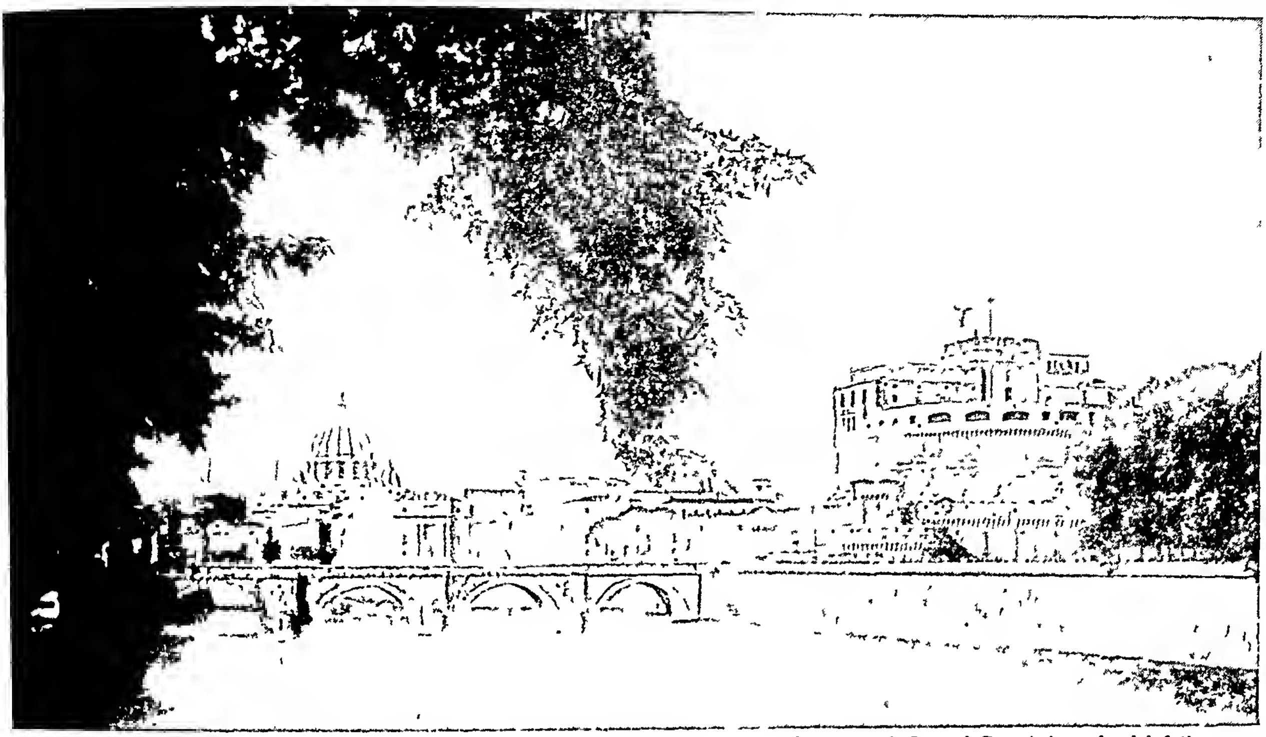
greatest extent. The capable and energetic Hadrian (117–138), consolidated and improved the organization of the empire and fortified the frontiers, building the great wall across northern Britain, parts of which stand to this day. The period of his wise rule and that of the philosopher-emperors Antoninus Pius (138–161) and Marcus Aurelius (161–180) was pronounced by one great historian to be the happiest era in the entire course of human history, if the welfare of the great mass of the population be considered. (*See* Marcus Aurelius Antoninus.)

After Marcus Aurelius, the decline of the empire set in. The legions had found that they could make emperors at will from among their own numbers, and they set up 80 such rulers in 90 years. The flood was finally stemmed by Diocletian (284–305), but he halted it by turning the Roman state into an oriental despotism, abolishing the last of republican liberty. The senate was now no more than the city council of Rome. Diocletian also took the first step toward dividing the empire. He entrusted an associate with the government of the West, while he himself ruled the East. Each ruler was known as an "Augustus," and each had a "Caesar" who was to help him rule and to succeed him upon his retirement or death.

The decline of Rome was consummated when Constantine moved his capital to the Greek city of Byzantium on the Black Sea (A.D. 330) and renamed it Constantinople in his own honor (*see* Istanbul).

The transfer of the capital meant ultimately a division of the empire. The story of the Byzantine Empire is a long and glorious one, that of the Western Empire from this time on merely one of weakness and decline (*see* Byzantine Empire). Gradually the northern barbarians seeped into Italy and in 410 Alaric took Rome. The Western Empire from that time became the prey of successive waves of barbarians. (*See* Alaric; Goths; Huns; Lombards; Vandals.)

In 476 Romulus Augustulus, the last of the imperial line in the West, who combined in his name that of Rome's legendary founder and that of her first emperor, was deposed by the barbarian leader Odoacer. The Roman Empire was at an end and the barbarian kingdoms of the Middle Ages were soon to take its place. But in reading the history of France, Italy, and Spain, you will realize that the end of the Roman Empire was in a way only its beginning. These new kingdoms governed themselves largely by Roman law, spoke forms of Latin, and professed the Christian religion. Thus, even though the great empire decayed and fell, Rome had won a new spiritual dominion, for the new faith spread throughout the lands which the Roman power had brought together but could no longer hold, and the seat of the great pagan power became the head of the Christian church. (For Reference-Outline and Bibliography, *see* Ancient History; *see also* Greek and Roman Art; Italy; Latin Language and Literature.)



These Are Symbols of Eternal Rome—the Tiber River, St. Peter's (left), and Castel Sant' Angelo (right)

ROME—"*The* ETERNAL CITY"

ROME, ITALY. Every year visitors from all over the world stream into Rome, the capital of Italy. The great city has something to share with everyone—pilgrim, scholar, art lover, and tourists from every land. Of all the cities in the world, only Rome is called "The Eternal City." Nearly 3,000 years old, Rome has survived invasions, plundering, fire, and bombings. Today magnificent ruins of the ancient Roman Empire rise in the heart of the modern city. Arches and columns of pagan temples stand among Christian churches. Stone fragments of aged market places lie near the busy squares, jetting fountains, and sunny outdoor shops that crowd Rome today.

Above all looms the great gray dome of St. Peter's, the largest church in the world and the goal of pilgrims from every Christian country. The majestic Renaissance dome, with its towering cross, can be seen from every part of the city.

Despite its age, Rome is lively and high spirited. Its people live with gusto and are ever ready with a quick laugh or song. They love their city and live out of doors as much as possible, enjoying their neighborhood fountains, gardens, and inexpensive cafés called *trattorie*. In even the poorest districts nearly every corner has a flower-decorated shrine, and the crowded apartments enjoy window boxes of bright blossoms.

The Location and Climate of Rome

Rome lies on the Tiber River in the west central part of the Italian peninsula, 17 miles from the Tyrrhenian Sea, an arm of the Mediterranean Sea. The city rises from a coastal plain of volcanic ash, the Campagna, and spreads over the low Seven Hills. These are simply ridges of the Campagna. The various parts of the sprawling city range in altitude from about 40 feet above sea level to about 270 feet. To the east, beyond the narrow Campagna, is the long line of the Apennine Mountains, easily seen from the city. At times the higher peaks are snow tipped (*see* Apennine Mountains). To the northeast are the Sabine Hills; and to the southeast, the Alban Hills.

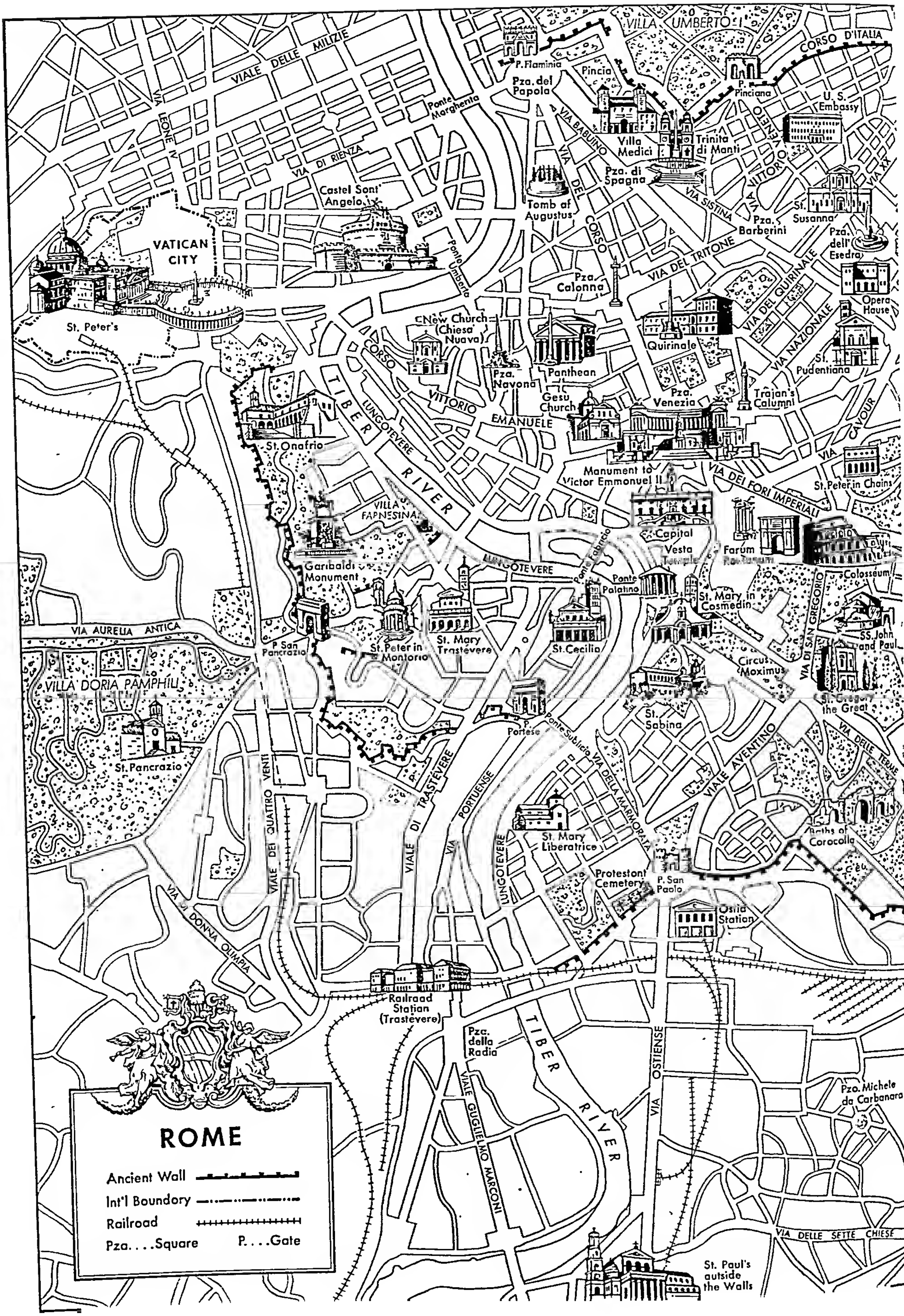
Rome is in about the same latitude as New York City, but it seldom has snow or even frost. Warmed by the Mediterranean Sea, Rome's annual average temperature is 61.5° F. Rome's thousands of gardens and miles of palm trees and oleanders thrive in its mild winters. Though summers are not as hot as those in the southern part of the United States, the sun blazes down through the clear blue sky, and most people seek the shady side of the street. After sundown, however, a fresh breeze cools the city.

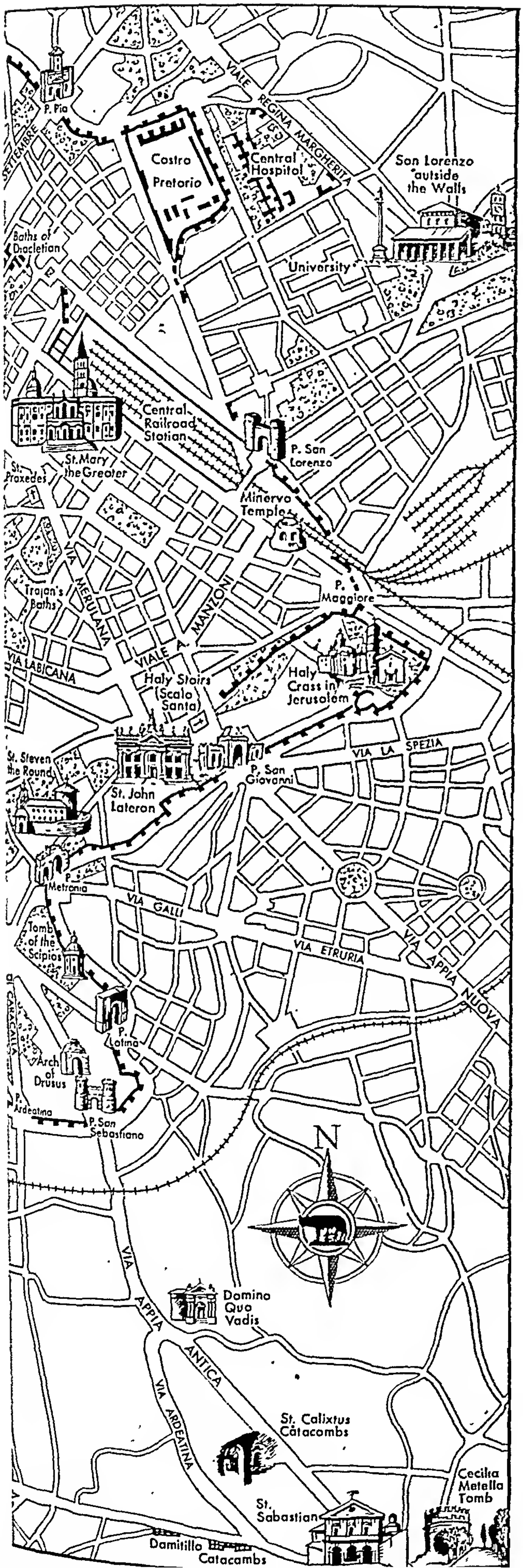
Sometimes in summer the hot, dry wind called the *sirocco* sweeps in from the south. In winter the *transmontana*, a north wind from the mountains, may bring storms. Most of the rainfall comes in the winter; summer has very little. Rome's many fountains, however, give a refreshing air to the city. Their cool "plash" sounds throughout the night.

On the next two pages is an illustrated map of Rome. The drawings of the notable buildings are actual representations.

Rome on the Right Bank and on the Left Bank

The slow-flowing Tiber River, tawny with clay, divides Rome (*see* Tiber River). The smaller part of the city stands on the west, or right, bank. Here are modern residential sections, several distinguished Catholic churches, and a very old district called


ROME
Ancient Wall
Int'l Boundory
Railroad
Pza. . . .Square
P. . . .Gate
VILLA UMBERTO I
CORSO D'ITALIA
P. Flaminia
Pincio
Pza. del Popolo
P. Pinciana
U.S. Embassy
VIALE DELLE MILIZIE
VIA LEONE IV
Ponte Margherita
VIA BABUINO
Villa Medici
Trinita di Manti
VIA VITTORIO VENETO
VIA XX
VIA DI RIENZA
Castel Sont' Angelo
Tomb af Augustus
VIA DEL CORSO
Pza. di Spagna
VIA SISTINA
Pza. Barberini
St. Susanna
Pza. dell' Esedra
VATICAN CITY
Ponte Umberto
VIA DEL TRITONE
Pza. Calonna
St. Peter's
New Church (Chiesa Nuova)
Quirinale
VIA DEL QUIRINALE
Opera House
VIA NAZIONALE
CORSO VITTORIO EMANUELE
Pza. Navona
Panthean
St. Pudentiana
Gesu Church
Pza. Venezia
Trajan's Calumn
VIA CAVOUR
LUNGOTEVERE
TIBER RIVER
St. Onafrio
Manument to Victor Emmonuel II
VIA DEI FORI IMPERIALI
St. Peter in Chains
VILLA FARNESINA
Capital
Vesta Temple
Farum Romanum
Colosseum
Garibaldi Monument
Ponte Fabricio
Ponte Palatino
St. Mary in Cosmedin
VIA DI SAN GREGORIO
VIA AURELIA ANTICA
P. San Pancrazio
St. Peter in Montorio
St. Mary Trastevere
St. Cecilia
SS. John and Paul
Circus Moximus
VILLA DORIA PAMPHILI
St. Sabina
St. Gregory the Great
P. Portese
Ponte Sublicio
VIA DELLA MARMORATA
VIALE AVENTINO
VIA DELLE TERME
St. Pancrazio
VIALE DEI QUATTRO VENTI
VIALE DI TRASTEVERE
VIA PORTUENSE
St. Mary Liberatrice
Baths of Corocolla
Protestont Cemetery
P. San Paolo
Ostia Station
VIA DI DONNA OLIMPIA
Railraad Station (Trastevere)
Pza. della Radia
VIALE GUGLIELMO MARCONI
VIA OSTIENSE
Pzo. Michele da Carbanara
VIA DELLE SETTE CHIESE
St. Paul's outside the Walls



This map of central Rome includes the important ancient ruins, Christian churches, and notable points of interest.

the Trastévere. On the right bank too stand St. Peter's, Vatican City (also called Vatican State), and Castel Sant' Angelo, once the home of the popes.

The major part of the city stretches eastward from the left, or east, bank. This part contains the ruins of the ancient Roman Empire. Included are the Colosseum, the Forum (Forum Romanum), the Baths of Diocletian and Caracalla, a column honoring Marcus Aurelius, and the Arch of Constantine. These and other great relics of the empire are described later.

Today's Rome on the East Bank

Many visitors to Rome arrive by plane or by bus, and a few by small boat; but most enter by train. They find a handsome Central Railroad Station. Opened in 1950, it is splendidly modern, yet—like much of Rome—it was especially designed to preserve an ancient ruin. Roman building law prescribes that new construction must not destroy any fragment of the empire. Just inside the garden walk of the new railway station stands a remnant of an empire street wall; and deep in a subbasement of the station rises another section of ancient wall.

Spreading out from the east bank are the government buildings, including the Capitol on Palatine Hill and the home of the president of Italy, the Quirinale on Quirinal Hill. Toward the eastern boundary is University City, built in 1932–35 to modernize the historic University of Rome.

Among the many shops, hotels, and *pensions* (boarding places) stand the embassies of the various nations. The United States Embassy is shown on the map, in the far north central part of Rome, on Via Vittorio Véneto. Rome has more diplomatic representatives of foreign countries than any other city, as almost every Christian nation sends diplomats not only to the Italian government but also to Vatican State.

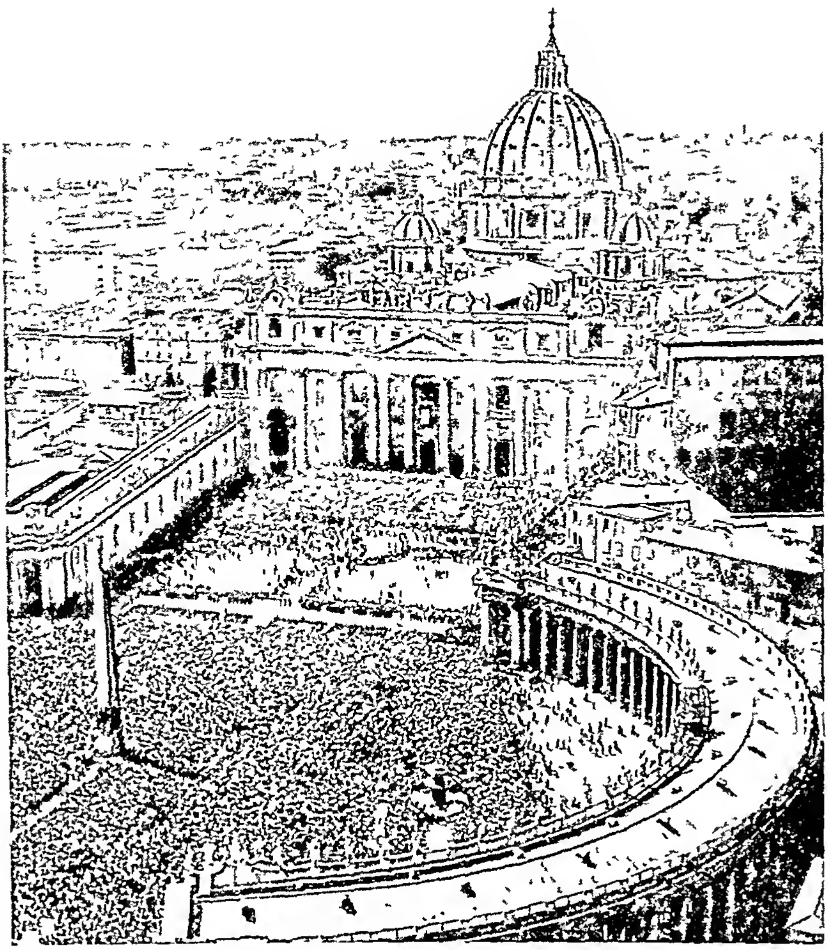
Ancient Wall Rims Heart of City

Much of modern Rome lies within the great wall begun by Emperor Aurelian in A.D. 271. He built it to defend the city against the onslaught of barbarian invasions. The massive wall is made of concrete, faced with bricks. It is some 13 miles in circumference, topped about every 100 feet by a watchtower.

Until about 1910 virtually all Rome lay within the Aurelian Wall. Since then, however, the city has spread out to about two and a half times that size. Its population today is more than 1,600,000, and the city is steadily growing. Since World War II the Romans have been building huge new apartment buildings in an effort to get adequate housing.

Most Romans, or *Romani*, prefer city life to suburban and an apartment to an individual house. They like to live among crowds, where daily living is spiced with cooking smells, the chatter of children, the gossip of "grownups," and the shouts of peddlers. Alleys, and sometimes broad avenues, are closed for several hours every morning to permit peddlers to set up their stalls of vegetables, meat, fish, and fruit. Over all the clamor rises the wild honking clatter of automobiles, motorcycles, and darting motor scooters. Rome, it has been said, is the world's noisiest city.

THOUSANDS WAIT TO SEE THE POPE



The tiny dots of people indicate the immensity of St. Peter's. It occupies part of the site of Nero's circus, where St. Peter was crucified. The pope stands on a center balcony.

Even as Rome expands today, it builds almost no suburbs. The large new apartment buildings merely extend farther and farther from the heart of the city. On the outskirts, Rome reaches almost directly into the country, where small farms are green with grapevines, gray with the soft dusty color of olive trees, and bright with truck gardens and tiny orchards.

Slums and Great Villas

Housing in the slums of Rome is shocking. Rickety tenements seem to lean on one another. Each is packed with people. Many wash at a street hydrant or in the fountain in the *piazza*, the open square that is the center of neighborhood life. There the women do their laundry, then string it along the street or out the tenement windows. These Romani live in deep poverty, yet every tenement has neat window boxes of flowers or green plants. The many, many children shrill gleefully at play on the cobbled streets beneath a corner shrine. At night there are songs, the melodies of accordions, and perhaps a glass or two of the light Roman wines. All Romani love to live.

Many wealthy Romans have splendid villas. Few, however, can be seen from the street. They usually stand behind terraced walls, which are covered by vines and flowers. Nearly every house opens into a beautifully kept garden, which serves as an outdoor living room or dining room. The garden is the heart of life in the villa. Trimmed cypress trees, laurels, and holly (ilex) shade the walks that lead always to a fountain.

Americans Invited to Ambassador's Villa

One magnificent villa is open once a year to all Americans in Rome. Each Fourth of July they may visit the Villa Taverna, the residence of the United States ambassador. Built in 1576 by Pope Gregory XIII, it was used as a seminary. The United States bought it in 1946. Its beautiful, old garden—laid out in the traditional Roman quadrangle—lies, like many Roman gardens, above catacombs.

The great villas are built largely of marble, travertine, and terrazzo (marble chips set in concrete and polished). Public buildings and other large structures are similarly built. The most common construction materials, however, are tufa, a porous dark red stone flecked with orange, and pozzuolana, a reddish concrete made from volcanic lava ash. All these materials give Roman buildings their characteristic whiteness or soft colors, although some of the postwar structures have gaudy modernistic tile or metal trims.

Industry and Transportation

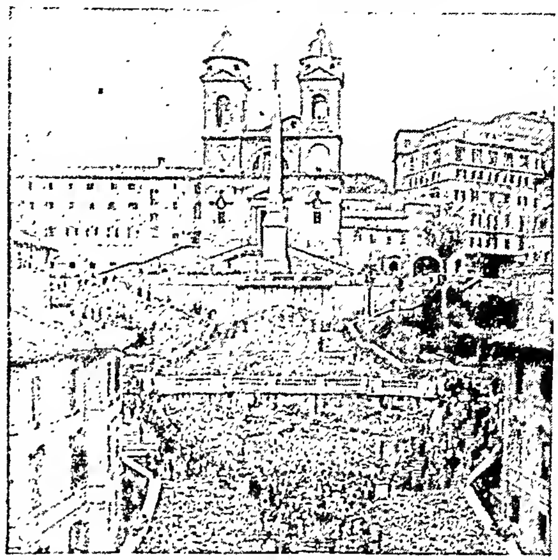
What do the people of this sprawling, exuberant city do for a living? Though it is the largest city in Italy and second only to Milan in manufacturing, Rome has relatively little heavy industry. Large-scale manufacturing did not develop until after World War I, and even today the comparatively few factories are almost entirely on the outskirts. This leaves the main part of Rome free from industrial smoke and helps keep the celebrated Roman sky bright blue.

The chief industrial products are machinery, automobile chassis, railroad cars, bicycles and motorcycles, foundry products, paper, printing, textiles, chemicals, and food products. Most of the people, however, work for the government or in handicrafts, in commerce, or in "service" trades. These trades include caring for tourists—such as in hotels, shops, and cafés. Tourism is a leading Roman industry.

Rome is especially noted for its handicrafts. From generation to generation, artisans in small shops carry down the secrets and skills that mark Roman

FAMOUS FOUNTAIN OF TREVI AND THE SPANISH STEPS

Marble tritons and sea horses struggle here as Neptune, center, watches. The huge fountain stands near the heart of Rome. The name Trevi comes from the Italian word *trivio*, "crossroads."



Massed shrubbery and flowers bank the Spanish Steps rising from Piazza di Spagna to Trinita di Monti. This Church of the Trinity was built in 1495 by Charles VIII of France.

leatherwork, silversmithing and jewelry, inlay work, mosaics, carving and molding, and bookbinding.

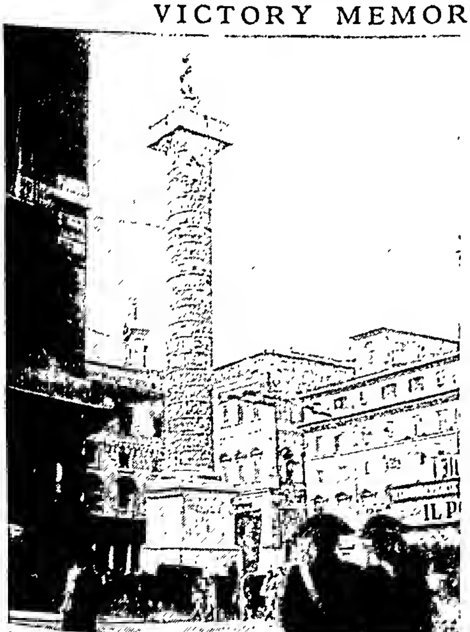
The city is a hub of international airlines and of the Italian railway system. Rome is threaded by interweaving lines of streetcars, buses, and trolley buses. For leisurely sight-seers there are horse-drawn carriages with top-hatted coachmen. The subway, started in 1938, is unfinished. The Tiber River is navigable for small craft. Bus lines connect Rome with Lido di Roma, the city's seaside resort.

Modern Rome Is a Center of Education

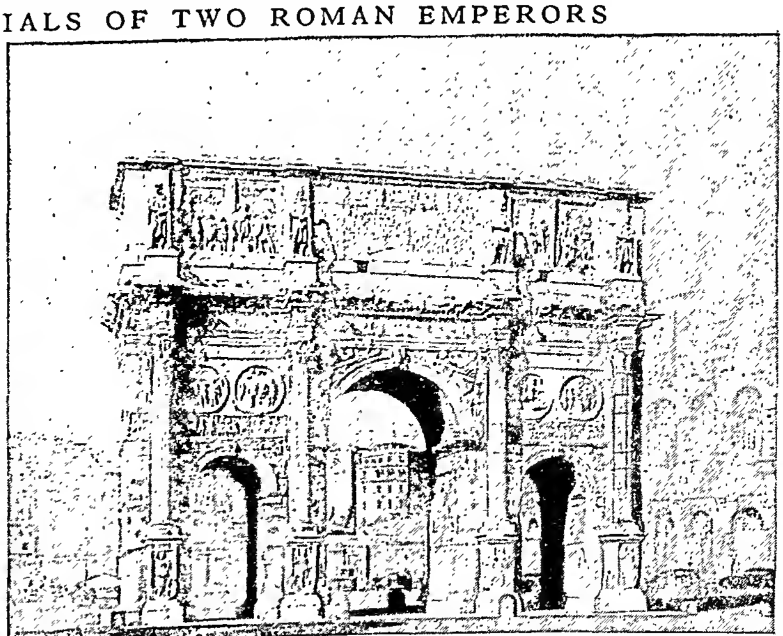
Rome provides extensive and unusually rich sources of learning. The great coeducational University of Rome, founded by Pope Boniface VIII in 1303, usually has about 40,000 students. Many of them come from foreign lands. The University is no longer controlled by the Catholic church; it is now nonsectarian.

One of the chief specialized institutes is the American Academy, founded in 1894, to provide further study in architecture and its allied arts by young men and women who have won the Prix de Rome. Another United States institution in Rome is the American School of Classical Studies. The oldest foreign advanced school is the French Academy, founded by Colbert in 1666, which serves exceptionally gifted young French artists. Others include the British School of

VICTORY MEMORIALS OF TWO ROMAN EMPERORS



The column of Emperor Marcus Aurelius is built of 28 marble blocks. An inside stairway leads to the top. The busy Piazza Colonna takes its name from the column, *colonna* in Italian.



The triple Arch of Constantine rises just west of the Colosseum. It is constructed of fragments of other monuments. Some of the reliefs were originally part of a monument to the great Trajan.

ST. PETER'S AND THE VATICAN RISE FROM PIAZZA SAN PIETRO

This great oval piazza is 787 feet wide and 1,115 long. The towering colonnade of Doric columns by Bernini on the right faces a duplicate colonnade across the piazza. Behind the colonnade, right, is the Vatican Palace. The dome is St. Peter's

Rome, specializing in archaeological studies; and advanced schools of architecture founded by Belgium, Sweden, Spain, and Egypt.

Rome also has the world's oldest academy of fine arts, the Academy of St. Luke, founded in 1478. The Academy of St. Cecilia, patron saint of music, is noted throughout Europe.

A great research organization, the International Institute of Agriculture, was founded in 1905 in Rome to obtain and distribute data on world crops and markets. In 1946 it became part of the Food and Agricultural Organization of the United Nations.

Rome has scores of distinguished general and special libraries, headed by the Vittorio Emanuele National Central Library. Vatican City has the world-famous Vatican Library, with about 75,000 manuscripts. In 1951 Jesuit scholars from St. Louis University, St. Louis, Mo., began to microfilm the priceless scripts for use in the United States.

Nearly every section of Rome houses a notable museum or art gallery—all open to the public. Their treasures range from antiquities, through the Middle Ages and Renaissance, and down to the present day. Master painters and sculptors decorated the many churches, and St. Peter's alone is a magnificent gallery of Michelangelo and Raphael masterpieces. The chief museums and galleries are described later.

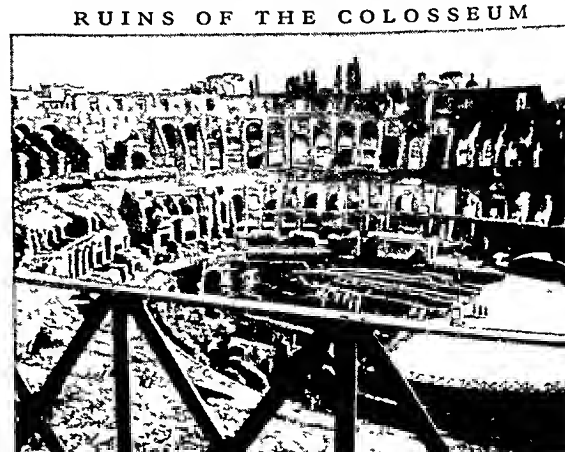
Plan of the City and Its Major Streets

Rome spreads out from its ancient site on the Seven Hills. These are now near the center of modern Rome. They are the Capitoline, Palatine, Aventine, Quirinal, Viminal, Esquiline, and Caelian hills. The city today also stretches west across the Tiber to Janiculum Hill and north to Pincian Hill. Both are favorite goals of visitors, for they afford superb views of the city reaching out below.

The busy center of modern Rome is the Piazza Venezia. From this great open square radiate many of the principal streets, as shown on the map. The chief artery, Via del Corso, leads north in almost a direct line to the Piazza del Popolo and the towering gate opening onto Via Flaminia—the old Flaminian Way that crosses the Apennines.

South from the Piazza Venezia runs Via dei Fori Imperiali, leading to the Colosseum and the Forum. A few blocks south of the Forum are the Baths of Caracalla. Running northwest from the Piazza Venezia, the Corso Vittorio Emanuele leads to the Tiber

RUINS OF THE COLOSSEUM



The oval arena is 620 feet long, 510 wide, and 160 high. After many of the stones had been removed to construct other buildings, Pope Benedict XIV stopped further demolition.

A PAPAL PROCESSION

Twelve bearers carry Pope Pius XII on the *Sedia Gestatoria* ("carried chair"), a gold and red velvet throne. He wears the papal triple crown. Chamberlains and Noble Guard escort him.

and, across the Tiber, to St. Peter's and Vatican City. Angling northeast from the Piazza Venezia, the Via Nazionale runs to the Piazza dell' Esedra, next to the giant ruins of the Baths of Diocletian. Built of marble and mosaics, they were the largest baths in ancient Rome, accommodating 3,000 people. From the Piazza dell' Esedra, the short Viale delle Terme leads southeast to the Central Railroad Station.

Tourists' Favorite Avenues and Piazzas

Luxury hotels, cafés, and shops line the stately Via Vittorio Véneto in the far north central part of Rome. It leads, through the Pincian Gate (P. Pinciana), to the Pincian Hill. Under the shade of tall plane trees (sycamores), visitors sit at outdoor tables among the potted plants and flowers that mark the boundary of each sidewalk café.

Another favorite street is Via Sistina, which angles northwest from the Piazza Barberini, the same square from which Via Vittorio Véneto leads. Handsome apartment buildings line the lower part of the avenue. As it climbs northwest, little art galleries, bookstalls, jewelry and handicraft shops, and sunny cafés appear in a gay jumble. The surrounding, crowded district resembles Greenwich Village of New York City.

Every one of Rome's great piazzas has its admirers, but visitors have favorites. Just west of Via Sistina, at the far end of the avenue, is the Piazza di Spagna, named after the nearby Spanish Embassy for the Vatican. This piazza, with its little boat-shaped fountain, is the heart of the artists' quarter. A massive baroque stairway, the Spanish Steps, leads down to the Flower Market, a mass of blooms. At the foot of the 137 steps is the house where the poet John Keats died in 1821. It is maintained as a memorial to Keats and Shelley and displays manuscripts, books, letters, and pictures of their time.

The Piazza Barberini and the Piazza Colonna are also popular with visitors. Small, delightful Barberini square, lying between Via Sistina and Via Vittorio Véneto, is dominated by the mighty Triton Fountain, sculptured by Giovanni Bernini in 1640. Just south of the square rises the enormous Barberini Palace, begun in 1625 for Pope Urban VIII. Bernini and his rival, Francesco Borromini, finished it in 1633.

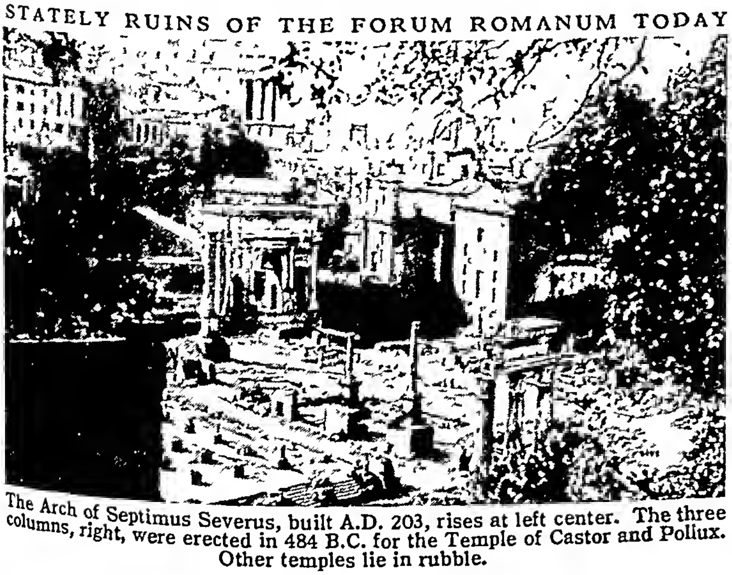
Piazza Colonna, on Via del Corso, is one of the busiest spots in Rome; yet it too has a handsome fountain. A marble column, honoring Emperor Marcus Aurelius, towers 97 feet above the square. Built about A.D. 176-193, the column is carved spirally with reliefs showing the emperor's victories over the German barbarians. At the top of the column stands a statue of St. Paul, placed there in 1589.

Fountains Inspire Poetry, Music

Every great city in the world has some beautiful fountains as showpieces, but in Rome fountains seem to be a living part of the city. Numerous poems describe them, catching their fascination of jetting, singing, murmuring cool water. One of Italy's greatest modern composers, Ottorino Respighi, immortalized them in his richly descriptive symphony, 'Fountains of Rome', first performed in 1916.

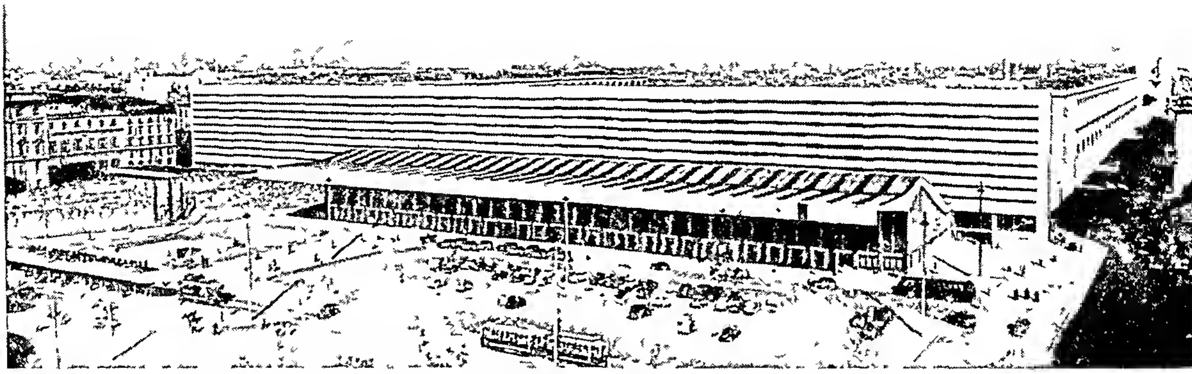
The most notable, perhaps, is Niccolo Salvi's Fountain of Trevi, just west of the Quirinale. Its water comes from an aqueduct built by Agrippa in 19 B.C. It is a tradition for visitors to cast a coin into the flashing water of the Trevi to insure, so legend says, their return to Rome. The most wildly imaginative fountain probably is Bernini's Fountain of the Rivers, north of the Corso Vittorio Emanuele. It portrays, in the form of giant statues, the Nile, the Rio de la Plata, the Danube, and the

STATELY RUINS OF THE FORUM ROMANUM TODAY



The Arch of Septimus Severus, built A.D. 203, rises at left center. The three columns, right, were erected in 484 B.C. for the Temple of Castor and Pollux. Other temples lie in rubble.

WHEN YOU GO TO ROME YOU MAY ARRIVE HERE



This is the Central Railroad Station, opened in 1950 to accommodate visitors to Rome for the 25th Holy Year. The station is the most modern and the best equipped in all Europe. Construction is still in progress, financed partly by Marshall Plan aid.

Ganges, surrounded by the flowers, plants, and animals characteristic of the four continents.

Museums and Art Galleries

Some of the richest exhibits of the sculptures, mosaics, musical instruments, and household and religious objects of ancient Rome are shown in the Capitoline Museum, the Venezia Palace Museum, the National Roman Museum, and Vatican Museum.

The great art galleries include the Villa Umberto I (formerly Villa Borghese), Colonna Palace, Corsini Palace, Doria Pamphili Gallery, the National Modern Art Gallery, and the magnificent historical rooms in the Vatican.

The City of Churches

Rome is the world's greatest religious center. As the home of the popes of the Catholic church, with the exception of the brief time they retired to Avignon, it was the headquarters of all Christianity until the Reformation (*see* Reformation). Through the Middle Ages, Rome and the church preserved much of the art, learning, and law of the empire (*see* Middle Ages). Today many of Rome's some 400 churches preserve masterpieces of the Renaissance.

Seven of the Catholic churches are "pilgrimage" churches. They are St. Peter's, St. Sebastian's, St. John Lateran, St. Mary the Greater, St. Paul's outside the Walls, Holy Cross in Jerusalem, and San Lorenzo outside the Walls.

The pope is always also the bishop of Rome. As pope he presides at St. Peter's; but, as bishop of Rome, his cathedral is St. John Lateran. The first cathedral on this site was consecrated in 324. Over the present-day St. John Lateran is inscribed in Latin—the language of the Catholic church—*Omnium Urbis et Orbis Ecclesiarum Mater et Caput*, "Mother and Head of all churches in the City and the World."

St. Peter's and the Vatican

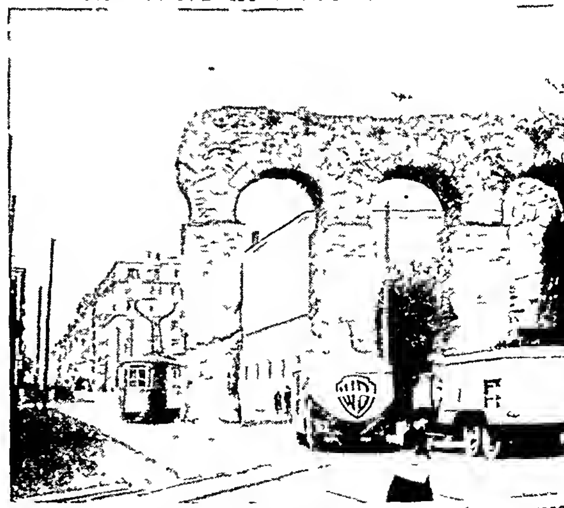
To people of all beliefs, St. Peter's presents a compelling majesty of history, art, and faith. The largest church in the world, it covers six acres, is 700 feet long, and 450 feet wide across the transepts. Some 80,000 people may stand in it. Built on the site of an earlier church, St. Peter's was begun in 1506 and finished in 1526. Few immediately realize its immensity, because it is perfectly proportioned. The massive yet graceful dome was designed by Michelangelo (*see* Michelangelo). The floor of the vaulted nave is inlaid marble, the ceiling of gold. The pope's altar stands above the tomb of St. Peter.

Adjoining St. Peter's is the Vatican Palace, home of the pope. It houses the Sistine Chapel, Michelangelo's masterpiece—the ceiling frescoes recording the creation of the world and the altar wall bearing his 'Last Judgment'. The Vatican galleries are crowded with great works of art. They include the 'Laocoon', the 'Apollo Belvedere', Greek, Roman, and Etruscan sculptures, and pieces by Fra Filippo Lippi, Fra Angelico, Bellini, and Raphael (*see* Raphael). (For a description of Vatican State, *see* Papacy.)

"The Grandeur That Was Rome"

The origin and development of Rome is told in the article on Roman history; but visitors to modern Rome

ANCIENT AND MODERN ROME



In the time of the Caesars this stone gate guarded an approach to Rome. Its adjoining walls were torn down as the city expanded. Today it looks out on streetcars, buses, and trucks.

can see today some spectacular traces of the grandeur that was the Rome of the Caesars. Present-day Rome actually stands above several earlier Romes, and archaeologists are still revealing remnants of those ancient cities. Until the dictatorship of Mussolini (1922-45), the great Forum Romanum was almost hidden from sight by a jumble of tawdry buildings, and the Colosseum stood in a mire of mud. Mussolini, determined to revive the spirit of the empire, tore down obstructions and built great avenues and squares to reveal the majestic ruins of ancient Rome.

The Forum was the heart of ancient Rome—the center of the daily life of business, marketing, and law. Today the ruins include columns and arches and worn stones of temples, memorials, and the palace of the Senators. South of the Forum is the Circus Maximus, the great sports field that could accommodate some 300,000 spectators.

Between the Forum and the Circus stands the awesome Colosseum, dedicated by Titus in A.D. 80. Now a gaping ruin, it once could seat some 50,000 people. Within its travertine walls, gladiators fought their bloody battles for life and "Christians were thrown to the lions" (*see* Gladiators). Emperors sometimes had it flooded for mock naval battles. Through the centuries rulers, popes, and nobility carried off tons of stone from its walls to construct new buildings, leaving it a broken shell today.

Near the Colosseum is the Arch of Constantine, the best preserved and most elaborate of the Roman arches. It was built in A.D. 311 to celebrate his triumphs. West of the Colosseum lie the flat remains of the Campus Martius (Field of Mars), the plain on the left bank of the Tiber where Roman legions drilled.

To the northwest, beyond the modern gigantic Monument to Victor Emmanuel II, is the Pantheon. Built in 27 B.C. it is the most perfectly preserved of ancient Rome's buildings. Today it is a Catholic church and the burial place of Raphael.

South of the Colosseum are the Baths of Caracalla, begun in A.D. 212. They covered about six acres and could accommodate some 1,600 bathers. It was in these impressive ancient ruins that Shelley wrote his 'Prometheus Unbound'. Today summer grand opera is given among the ancient stone columns.

"All Roads Lead to Rome"

Stemming southeast from the Baths of Caracalla is the Appian Way (Via Appia Antica), built by Appius Claudius in 312 B.C. The great road, 18 feet wide, paved with stone and basalt, was a military highway (for pictures, *see* Roads and Streets). A marvel of Roman engineering, it is still in use today.

Remnants of ancient Roman roads can be found throughout Europe today. They were the routes of supply for the conquests that built the Roman Empire.

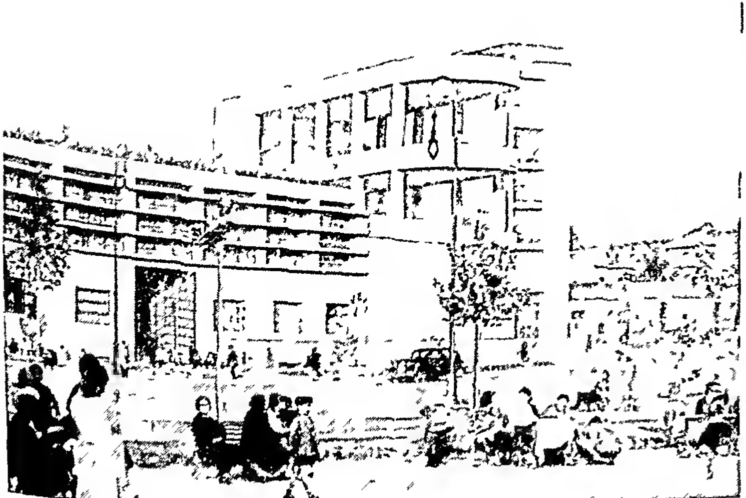
The Tombs and Catacombs of Rome

Ancient Roman emperors not only tried to outdo one another in the magnificence of their palaces but also in the imposing structure of their tombs. Hadrian, for example, spent years designing his own tomb—and died before it was finished. Today it is the Castel Sant' Angelo, once the home and refuge of popes, who converted it into a fortress. It is a short distance northeast of St. Peter's on the Tiber.

Ancient Roman law forbade burial within built-up areas of the city, and so many of the roads were lined with tombs. Several of the most imposing still line the Appian Way. They include the Tomb of the Scipios, among the greatest of Roman generals, and the supposed tomb of Seneca, the brilliant philosopher, statesman, and dramatist of the Empire.

Most pagan Romans were cremated; but Christians believed in resurrection and so embalmed and buried the dead in cemeteries. When persecution began under the later Roman emperors, Christians dug tunnels in the soft tufa rock and placed their dead far underground in galleries. These underground galleries are the catacombs. They are reached by the Appian Way.

AT PLAY AND AT WORK IN THE ROME OF TODAY



This is one of the many recreation centers that dot Rome today. The building is a playhouse for children. This is one of a number of social welfare projects for the underprivileged.

A local piazza is the center of life for every neighborhood in Rome, even in the poorer quarters. Here a fisherman cleans his catch of squid. Even this square has a little fountain.

IN A CATACOMB

This is a child's crypt in the Catacombs of St. Calixtus on the Appian Way. The wall bears the painting of five maidens. The catacombs also served as a refuge for the persecuted Christians.

As persecution mounted, Christians literally went underground to hold their services in the catacombs. They extended them into a maze of tunnels, criss-cross and up and down, lighted and ventilated by ingenious air shafts. They kept the porous tufa rock dry, preserving the burial places.

Notable catacombs on the Appian Way today include the Catacombs of Domitilla, founded at the end of the 1st century A.D. by Flavia Domitilla, a niece of Emperor Domitian. Others are the catacombs of St. Sebastian and St. Calixtus. Many galleries bear still legible inscriptions. The word catacomb comes from Greek *kata,* "down," and Latin *tumba,* "tomb." Population (1951 census, preliminary), 1,606,739.

'ROMEO AND JULIET'. The world's most famous romance is Shakespeare's tragic drama of Romeo and Juliet. Written in 1596, when Shakespeare was only 32 years old, 'Romeo and Juliet' has been played every year since then throughout the world. The play was made into grand opera by Gounod in 1867.

The story of the young lovers is set in Verona, Italy. Beautiful Juliet, only 16 years old, is presented at a masque party by her father, head of the House of Capulet. She is an only child, and proud Capulet plans to betroth her to the count of Paris.

Romeo Ventures into the Capulet Home

In mischief, young Romeo Montague puts on a disguise and goes to the masque, despite the fact that the Montagues and Capulets are bitter enemies. At the masque, Romeo and Juliet fall in love.

During the famed balcony scene, Juliet laments that Romeo bears the name of the rival Montagues, as otherwise her father might not oppose their love:

> O Romeo, O Romeo! Wherefore art thou Romeo?
> What's in a name? That which we call a rose
> By any other name would smell as sweet; . . .

Impetuously, within a few days they are married by a friendly priest, Friar Lawrence. That same day Romeo gets involved in a street quarrel, in which his friend Mercutio is killed by Tybalt, a Capulet. In revenge, Romeo kills Tybalt and is banished.

Meanwhile, Juliet's father, unaware of the secret marriage, orders her to prepare to marry the count of Paris. To escape, she takes a drug given to her by Friar Lawrence to put her in a deathlike trance until word can be sent to Romeo to come and take her away.

Romeo, however, is mistakenly told that Juliet is dead. Rushing back to Verona, he breaks into her crypt and takes fatal poison. Waking from her trance, the horrified Juliet seizes Romeo's dagger and kills herself. Ironically, when the Capulets and Montagues learn of the tragedy, they become reconciled.

Shakespeare took his plot from a poem written by Arthur Brooke in 1562, titled 'The Tragicall Historye of Romeus and Juliet, containing a rare example of love constancie, with the subtill counsels and practices of an old Fryer'. The story had appeared even earlier, in 1554, in 'Novelle', by Matteo Bandello, an Italian novelist and bishop.

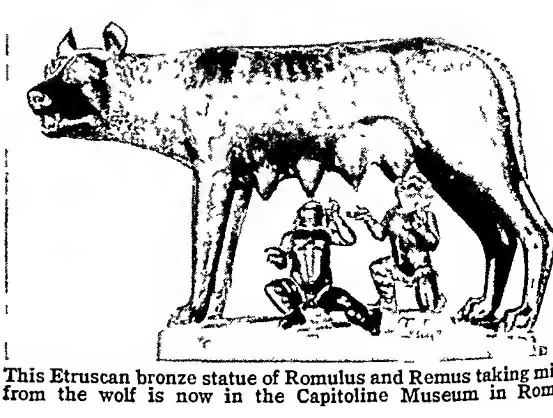
ROMULUS AND REMUS. *The mythical founder of* Rome was Romulus. He and his twin brother, Remus, were sons of Mars, the god of war, and Rhea Silvia, a Vestal Virgin. Rhea, the daughter of Numitor, king of Alba Longa, was said to be a descendant of the Trojan hero Aeneas, son of Venus (*see* Aeneas).

Amulius, younger brother of Numitor, overthrew him, imprisoned Rhea Silvia, and ordered servants to cast the infants Romulus and Remus adrift on the Tiber River. The Tiber was in flood, and the high waters safely carried the twins' basket to the riverbank. There a she-wolf found them. She nursed them and cared for them till they were found by Faustulus, the king's herdsman. He and his wife reared the twins.

When they grew to manhood, they killed Amulius and restored Numitor as king. The twins then determined to build a city at the spot on the Tiber where they had been saved. Remus selected Aventine Hill as the site; Romulus insisted on Palatine Hill. In the quarrel that followed, Remus was killed. Romulus then built the city, in 753 B.C. To hasten its growth, he made it a refuge for outcasts and fugitives.

After about 40 years of rule, Romulus, it is said, was caught up into the sky in a great storm to dwell with his father, Mars. The ancient pagan Romans then worshiped Romulus under the name of Quirinus.

WOLF FEEDS THE TWINS



This Etruscan bronze statue of Romulus and Remus taking milk from the wolf is now in the Capitoline Museum in Rome.

CHAMPION *of the* NEW DEAL *and* WORLD ORDER

ROOSEVELT (*rō'zĕ-vĕlt*), FRANKLIN DELANO (1882-1945). As the leader of the American people in a grave domestic crisis, and as one of the three chief leaders of the United Nations in the most terrible war the world has seen, Franklin D. Roosevelt occupies an unforgettable place in history. His death in the spring of 1945, less than three months after the opening of his fourth term as president, closed an era in American affairs. It came when the American armies, allied with the British, Russian, and French, were steadily eating deeper into Germany and were within sight of final victory. It came when the army, navy, and air forces in the Pacific had all dealt Japan such heavy blows that she could not hold out more than six months longer.

President Roosevelt had played a principal part in laying the plans which brought the triumph of the United Nations so near. Although it was tragic that he could not gather the laurels of victory, they were safe. In a double sense a new era was opening. Thanks largely to his vision and tact, the United States was renouncing isolation and preparing to do its full share in a permanent world organization. Meanwhile as peace came, the country would turn back to tasks of readjustment and reorganization at home. In this it would build on the "New Deal" foundations laid under Roosevelt's guidance.

THE ARCHITECT OF VICTORY

Here is Franklin Roosevelt as he looked at the start of his fourth term. With victory assured in the second World War he was in the midst of long-range plans for world peace when death came to him.

Both in domestic and foreign affairs, Roosevelt's 12 years as president marked a sharp turning point in American policy. At home the country adopted measures which gave most citizens greater security—security against loss of work, insufficient wages, overlong hours, and poverty resulting from sickness or other misfortunes. Abroad it determined to act with other nations in systematic efforts to abolish war, and promote world unity. The crowded events of these 12 years make Roosevelt's career one of the most interesting of modern times, and give him a place with Washington, Lincoln, and Woodrow Wilson as a world figure.

Advantages in Early Training

Few presidents have been reared in such favoring circumstances as Franklin D. Roosevelt. He was born Jan. 30, 1882, at the family estate near Hyde Park, New York, overlooking the Hudson. His father, James Roosevelt was a wealthy landowner, vice-president of a railroad, and a minor member of the diplomatic service under President Cleveland. His mother, Sara Delano, was an exceptionally able woman who sprang from an old merchant-shipping family. Franklin was a fifth cousin of President Theodore Roosevelt, both being descended from the Claes van Rosenvelt who entered America from Holland about 1649. In Franklin's veins ran also English and French Huguenot blood.

A well-rounded education began when Franklin was first taken to Europe at the age of three. The boy traveled widely, mastering French and German. He became adept in the sports of the Hyde Park community—riding to hounds, swimming, skating, shooting, polo, and tennis. Summer vacations on the Bay of Fundy made him a passionate lover of sailing. Growing interested in naval history, he began a collection of books, prints, and ship models that eventually became very valuable. From private tutors he passed through Groton School, entering Harvard in 1900. There he studied hard, took part in football and rowing, and became president of the *Crimson*.

After graduation he entered the Columbia Law School, where he completed his work in 1907, and began practise with a leading New York law firm. Meanwhile, in March 1905, he had married Anna Eleanor Roosevelt, his sixth cousin. President Theodore Roosevelt, her uncle, came to New York to give away the bride. The two frequently saw "T.R.," whose liberal ideas and aggressive leadership had a great influence on Franklin. From him the young man absorbed an ambition to excel in public life.

Paying frequent visits to his native Hyde Park, Franklin took a prominent place in the business, religious, and philanthropic affairs of Dutchess County. Democratic leaders saw that he would make a popular figure in politics. In 1910, when the progressive current was running strong, they arranged his nomination for state senator. The three counties of the Twenty-sixth District were strongly Republican, but this year the opposition was divided. Roosevelt made a strenuous automobile tour, delivered dozens of speeches, and impressed voters with his vibrant personality. Elected by a narrow margin, he went to Albany a marked figure.

As Theodore Roosevelt had done 30 years earlier, he at once made a legislative record for courageous independence. Tammany Hall had determined to elect William F. Sheehan, who represented boss politics, to the United States Senate. Roosevelt led a Democratic group which by an unrelenting battle defeated Sheehan. He fought other Tammany measures which favored special interests. Attacking certain traction corporations, he labored for fuller regulation of public utilities. In 1912 he was re-elected to the state senate. This time he pushed important bills to promote rural coöperation and stop unfair practises by commission merchants. Throughout his life Roosevelt regarded himself as an active farmer and liked to be called a country squire.

War Service Under Woodrow Wilson

The breaking in 1912 of the long Republican hold upon the presidency threw new fields of service open to Roosevelt. It became evident in 1911 that the Republican Party would be split in two, making Democratic victory almost certain. Franklin ardently supported the nomination of Woodrow Wilson, whose intellectual power and progressive ideas impressed him. He made speeches, wrote letters, and led an influential delegation of a hundred and fifty citizens to the Democratic Convention in Baltimore. His work was noted with approval, and when the Wilson Administration came into office in March 1913, it offered him several posts. He chose to follow Theodore Roosevelt's example and became assistant secretary of the navy. "All my life I have loved ships and been a student of the navy," he said.

For four years, 1913-17, Roosevelt was Secretary Josephus Daniels' principal aide in enlarging the navy and making it more efficient. For four more years, 1917-21, he was the secretary's tireless helper in using the navy to help defeat Germany, and in its postwar reorganization.

When the United States went to war in 1917, Roosevelt was anxious to enter the armed forces. "Tell the young man," Wilson said to Daniels, "his only and best war service is to stay where he is." The assistant secretary stayed and labored night and day. He was active in enlarging the navy yards and improving their methods. He built up the supply services. He supervised labor relations. And he gave special attention to securing additional recruits, for a navy of about 75,000 men had suddenly to be expanded to one of half a million.

His most striking achievement, however, was in dealing with German submarines. President Wilson had suggested that "the hornets be shut up in their nests." Roosevelt prepared a long memorandum to show that the English Channel and North Sea could be closed by a mine barrage. Various American and British officers pronounced the scheme impossible. But by persistent effort it was pushed through. At a cost of 80 million dollars, a belt of mines 30 miles wide and 230 miles long was laid between the Orkneys and Norway. This feat was an important element in defeating the submarine threat.

A midsummer inspection trip to Europe in 1918 aboard a destroyer was followed by a post-armistice sojourn abroad, in which Roosevelt supervised demobilization plans and looked after the disposal of surplus naval property. Meanwhile he had learned much from Wilson at home. Everybody recognized that this dynamic young man had a bright future. Daniels commented on a photograph which showed him looking smilingly from a Navy Department window toward the White House. "You are saying to yourself," he said, "'Some day I shall be living in that house.'"

Personal Disaster and Its Conquest

Roosevelt was a strong believer in the principles of the League of Nations. In the presidential campaign of 1920 the Democratic party, still dominated by the stricken President Wilson, made its fight on a League platform. Roosevelt hoped to see his friend Gov. Alfred E. Smith of New York nominated, and worked for him in the convention. The honor went instead to Gov. James M. Cox of Ohio. This made it advisable to choose a vice-presidential candidate from the East, and the delegates chose Roosevelt, whose war service, family name, and New York residence made him highly eligible.

ROOSEVELT'S ADMINISTRATIONS 1933–1945

Banking Holiday proclaimed and Gold Standard suspended (1933)
Tennessee Valley Authority organized (1933)
Industrial recovery program started under NRA (1933)
Banking laws revised and bank deposits insured (1933)
Federal Unemployment Relief provided (1933)
Prohibition repealed (1933)
Stock Exchanges brought under Federal regulation (1934)
Federal Housing Program (1934)
Reciprocal Tariff Act (1934)
NRA and AAA declared unconstitutional (1935)
Social Security Act (1935)
Right of collective bargaining guaranteed to Labor (1935)
Soldiers' Bonus Act (1936)
Re-elected for second term (1936)
Reorganization of Supreme Court defeated (1937)
Fair Labor Standards Act (1938)
New Agricultural Adjustment Act (1938)
Neutrality Laws (1935–37, 1939)
Executive Departments Reorganized (1939–40)
Largest peacetime Defense program set up (1939–40)
Re-elected for third term (1940)
"Lend-Lease" Act (1941)
"Atlantic Charter" (1941)
War with Axis Powers (1941)
"G.I. Bill of Rights" (1944)
Re-elected for fourth term (1944)
Discussion of peace plans with Churchill and Stalin (1945)
Death of President (1945)

A memorable scene took place in the White House when Cox and Roosevelt, visiting the half-paralyzed Wilson, solemnly promised to fight to the end for the League. In nationwide tours they kept that promise, advocating unconditional entry into the world organization. Roosevelt made more than a thousand speeches. But it was impossible to halt the revolt of a war-weary country against Democratic policies. When the ticket was buried under a landslide vote, he cheerfully returned to New York to join two Harvard classmates in the law firm of Marvin, Hooker, and Roosevelt.

Within less than a year he was felled by what seemed a terrible calamity. Infantile paralysis became rife in many places in the summer of 1921. Roosevelt, going to his cottage at Campobello, New Brunswick, for a vacation, received word that a forest fire was raging near by. With two of his sons he spent strenuous hours clearing breaks and wetting underbrush. Then, half-exhausted, he went for a swim in the cold Bay of Fundy, returned home, and sat down in his wet bathing suit to read his mail. He retired to bed with what he thought was a heavy cold, and found that infantile paralysis had gripped him. His legs were paralyzed.

PICTURES FROM THE FAMILY ALBUM

These photographs show Franklin Roosevelt in his early years. 1. Seven-year-old Franklin sits astride his favorite pony. 2. Eight years later he poses (front row, middle) with his football teammates at Groton School. 3. Also an ardent baseball fan, Franklin (top row, without uniform) managed Groton's baseball team. 4. Franklin with his fiancee (and sixth cousin), Anna Eleanor Roosevelt, shortly before their marriage.

Yet this seeming disaster gave Roosevelt's career renewed impetus. Deprived of active physical employments, he developed his mental powers. Undertaking by desperate exertion of the will to regain part of his lost muscular control, he became more tenacious and indomitable. As he made progress, his optimism and self-confidence increased. "Once I spent two years in bed trying to move my big toe," he said later. "After that job, anything seems easy."

Careful exercise, with winter treatments and swimming at Warm Springs, Ga., brought back his strength. He continued active legal practise, founding the firm of Roosevelt & Connor in 1924. The same year he reappeared in politics at the Democratic Convention proposing the nomination of Alfred E. Smith for president. Though Smith was not chosen at this time, Roosevelt's speech on the "Happy Warrior" became famous. To benefit other infantile-paralysis sufferers he helped establish a valuable therapeutic center at Warm Springs. His correspondence with political leaders throughout the country gave him a national following.

The Governorship of New York

In 1928 Smith, after four terms as governor of New York, was at length chosen by the Democrats to run for president. Roosevelt once more had made the nom-

inating speech. To strengthen the ticket in New York Smith and others prevailed upon him to become a candidate for governor. In an exciting election he rallied both rural and urban support, and carried the state by about 25,000 votes, although New York's presidential choice went to Hoover by more than 100,000 votes.

His governorship was not spectacular. "Al" Smith had made New York one of the most progressive of all states; Roosevelt simply kept it in that position. As yet he showed neither marked power in originating new policies, nor great boldness in carrying them out. His most notable fight was against the electric interests which he accused of trying to seize the water power of the St. Lawrence on unfair terms. He championed old-age pensions and unemployment insurance, and, despite strong opposition, won an Old-Age Security Act which provided some benefits, though not all that he had asked. He also obtained a law which limited the working hours of women and children. At his instance measures were put into effect for farm relief, for the transfer of rural population from submarginal land to better homesteads, and for reforesting waste areas. As hard times came on in 1930, he championed a broad relief program.

That year he was re-elected governor by the unprecedented plurality of 725,000 votes. His tremendous victory turned all eyes on him as a possible president. He continued his progressive course, hammering at better regulation of public utilities, court reform, and more intelligent attention to public health and housing. He favored organized labor, and attacked prohibition. But in dealing with corruption in New York City he moved cautiously. He removed a sheriff convicted of wrongdoing, and took steps which brought about the resignation of Mayor James J. Walker, but seemed anxious not to offend Tammany. On the whole his governorship was quietly successful.

When the stock market crash of 1929 threw the nation's economic system into disorder and an appalling depression began, his vigorous relief policies convinced the sufferers that he was intensely sympathetic with their plight. Month by month conditions grew worse. Within three years the national income was cut in two. Multitudes lost their jobs, until by the end of 1932 probably 12 millions were out of work. Mortgages were foreclosed on hundreds of thousands of farms and city homes. Bank failures swept away the savings of countless people. Factories shut down, mines closed, railroads went into bankruptcy, and worst of all, many lost all hope. The country looked desperately about for a new leadership.

Election to the Presidency

Few presidential campaigns have been more dramatic than that staged in 1932 against the background of the grim depression. It was almost a foregone conclusion that the Democratic candidate would defeat Herbert Hoover, whom millions mistakenly blamed for the hard times. But who should the nominee be? Some supported Newton D. Baker of Ohio, some John N. Garner of Texas, and some Smith of New York. Roosevelt strove earnestly for the prize. He was favored by his record, his popularity in strategic New York, and his personality. He had also the advantage of an astute organization.

A remarkable political manager, James A. Farley, undertook to win delegates for Roosevelt throughout the country. He sent out booklets describing the achievements in New York and explaining Roosevelt's powers as a vote-getter. He wrote letters to many thousands of people. He had Roosevelt talk by telephone to innumerable political leaders throughout the country. Agents were scattered over the land, writing for newspapers and buttonholing influential men. In the spring of 1931 headquarters were opened in New York City. The consequence was that long before the convention met, Roosevelt had a strong lead. "Al" Smith was eager for the nomination, and felt that Roosevelt should step aside to let him have it, but to his intense bitterness found that his chances were slight.

As the convention approached, Roosevelt strengthened his hold on the public by several notable speeches outlining part of his program for rescuing the nation. He had gathered a little group of experts, the "Brain Trust," who helped him put his ideas in shape. They endorsed his program of emphasizing the economic issue. In a speech of April 1932, he declared that the country faced a graver crisis than in 1917, and that it must build from the bottom up and not from the top down. He spoke of "the forgotten man at the bottom of the economic pyramid" as the person the government must assist. Calling for a national program of restoration, he declared that it must include assistance to farmers, relief to small banks, aid to home owners, and promotion of international trade by tariff reduction. A little later, at Oglethorpe University, he called for bold, persistent experimentation. With the nation in such distress, it was common sense to try one plan, and if it failed, try another. "But above all, try something. The millions who are in want will not stand by silently forever while the things to satisfy their needs are within easy reach."

These speeches made a profound public impression. When the convention opened in Chicago, Roosevelt had a clear majority. But he lacked the required two-thirds, and danger arose that the other candidates would all combine against him. Farley prevented this by keeping votes in reserve, and at the critical moment making an alliance by long-distance telephone with John N. Garner which resulted in the release of Texas and California delegates to Roosevelt. This was decisive. On the fourth ballot, amid a storm of cheers, Roosevelt was nominated. Garner received his reward in the vice-presidential nomination.

Confident of the outcome, Roosevelt had already prepared his acceptance speech. While his friends saw that the convention was held in session an extra day, he took an airplane to Chicago, received an uproarious reception, and delivered his address in person. This unprecedented act showed that he cared little

for tradition and was prepared to act boldly. It also proved that his attack of infantile paralysis would not hamper him in the presidency. "I pledge myself to a new deal," he said, adding: "This is more than a political campaign; it is a call to arms."

A strenuous canvass by radio and rail followed. The keynotes of Roosevelt's appeal to the voters were simplicity, directness, and boldness. He had seen to it that the Democratic platform was brief, practical, and full of definite proposals. Now he made a series of addresses, each handling some definite phase of national affairs. In Kansas, for example, he discussed the farm problem and proposed what later became the domestic allotment scheme, by which farmers agreed to plant under government direction and receive government benefits. In Oregon he dealt with the water power question and the regulation of public utilities, making suggestions that later blossomed into the great dams on the Tennessee, Columbia, and other rivers. A comprehensive speech to the Commonwealth Club of California dealt with social welfare, the relations between government and business, and the necessity for restoring equal economic opportunity. At Atlanta he declared that the most urgent task was re-establishing the purchasing power of 50 million people. Altogether, Roosevelt's campaign journeys covered 38 states. Everywhere he talked with as many people as possible: farmers, stockmen, factory hands, small businessmen, clerks, miners, and newspapermen.

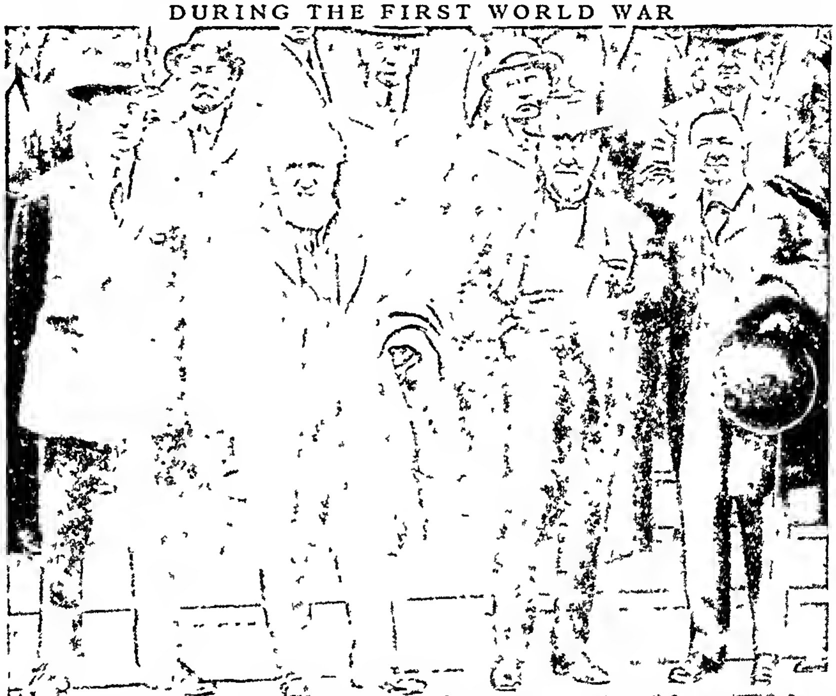
Though President Hoover fought a vigorous battle, denouncing Roosevelt's philosophy as certain to endanger the American system and predicting that under it "grass will grow in the streets of a hundred cities, a thousand towns," public sentiment was with the cheery, magnetic, and trenchant new leader. On election day, Roosevelt carried every state but six. He had a popular plurality of nearly seven million votes, and his majority in the electoral college was the greatest since the one-sided election of 1864.

The Depression Reaches a Climax

Nearly four months had to elapse between Roosevelt's election and his inauguration. In this period he was busy finishing his term as governor, planning his initial measures, and selecting his Cabinet. He decided to call a special session of Congress and ask it to pass bills protecting farmers against the foreclosure of mortgages; giving farmers relief by the domestic allotment plan; helping business by better bankruptcy procedure; and legalizing the sale of beer. He would also coöperate with Congress to balance the budget, and would urge the repeal of the prohibition amendment.

For secretary of state he decided upon Cordell Hull, a man of Wilsonian ideas on world affairs, a pronounced believer in lower tariffs, and a veteran in Congress, where his popularity would be helpful. He chose for the Treasury department an old friend, William H. Woodin, president of the American Car and Foundry Company, who was later to be replaced by Henry Morgenthau, Jr. The Postoffice department went to his astute political manager, James A. Farley. But the most interesting choices were two which showed that Roosevelt wished to unite the Democrats and Progressive Republicans in a firm alliance. Henry A. Wallace, a young farm editor of Iowa who had been a Republican, and whose father had sat in the Harding-Coolidge Cabinet, was selected for secretary of agriculture. Harold L. Ickes, a follower of Theodore Roosevelt and a friend of various Progressive senators, was chosen for secretary of the interior. In addition, Roosevelt decided to make Miss Frances Perkins, well known as a social worker, secretary of labor—the first woman Cabinet member. The whole group, said Roosevelt, was "slightly left of center."

DURING THE FIRST WORLD WAR



As assistant secretary of the navy, Roosevelt worked hard to increase the size and efficiency of the American fleet. Here we see him (left) with the famed inventors, Hiram Maxim and Thomas Edison, and Secretary of the Navy Josephus Daniels (extreme right).

In the winter of 1932-33 the state of the country became tragic. Industrial production, measured by percentages, fell to the lowest level ever recorded. The "index" for this production had been 91 in 1925, and 110 in 1930; it sank to 58 in 1932, and for the winter months was 52. The country's energies seemed paralyzed. In city streets desperate men sat peddling apples for a bare living. Unemployed workers, hopelessly tramping the country, drifted into villages of shacks. Long lines of men gathered for a bowl of soup and a free bed. Yet the farm districts were full of food for which there was no market, and farmers

were assembling in mobs in the West to stop foreclosures. In factory towns, hardly a mill wheel moved, hardly a chimney showed smoke. The railroad trains ran empty. As the economic chill struck deeper, banks failed by hundreds. In January 1933 bank depositors became frightened, and began to withdraw their savings in panic.

President Hoover wished Roosevelt to cooperate in certain emergency measures. But Roosevelt took the view that so long as he had no authority in the government, he ought not to take even partial responsibility for its acts. More important, he completely disagreed with Hoover as to the basic causes of the depression. Hoover argued that domestic recovery had already begun, but had been checked by disturbances and depression in Europe. Roosevelt held that home recovery was not yet under way; that its chief root was lack of purchasing power among the people, and that radical domestic reforms were imperative.

The first days of March 1933 saw the crisis reach its climax. By March 2, more than 20 states had declared bank holidays to stop the panic. Then Governor Lehman closed all the banks and stock exchanges of New York, and Governor Horner did the same in Illinois. By the morning of March 6, banking operations had been officially suspended throughout the country. The economic life of the nation was almost at a standstill. Not since Woodrow Wilson had gone before Congress in 1917 to ask for a war against Germany, had the country known so anxious a moment. One hundred and thirty million Americans waited with the tensest anxiety.

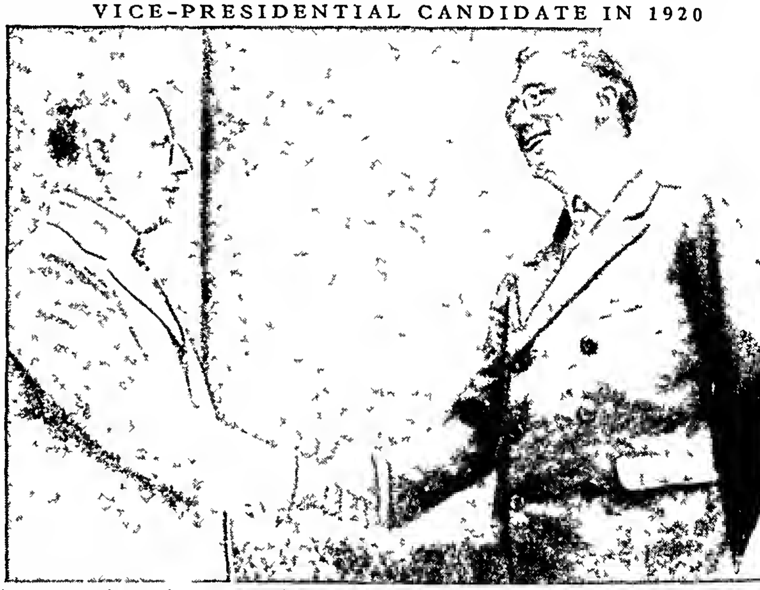
The Crisis Measures of the "Ninety-Nine Days"

At a little after one o'clock on March 4 the radio carried Roosevelt's voice throughout the nation in an inaugural address which did much to restore public confidence. He called for courage—"the only thing we have to fear is fear itself"; he assailed the practises of business—"rulers of the exchange of mankind's goods have failed through their own stubbornness and their own incompetence"; and he promised constructive steps—"action, and action now." He proposed to raise farm prices, reorganize relief activities, furnish stricter supervision of banking, credits, and investments, reduce government costs, and recruit young men for work as if the country were at war. In short, he would take action against the depression along a broad front.

The first step was to deal with the banking crisis. Congress, heavily Democratic in both houses, was called to meet in special session March 9. On that date Secretary Woodin had an emergency banking bill ready. Ordinarily, businessmen would have opposed hurried government action. But the gravity of the crisis, the threat of general bankruptcy, and the fact that many bankers had been guilty of disgraceful abuses, made all interests willing to accept what Roosevelt urged. The banking bill was rushed through Congress in four hours, with an almost unanimous vote. All banks were to be subject to sharp government scrutiny; only those in sound condition were to be allowed to reopen; these sound banks were to be strengthened by the issuance to them of Federal Reserve notes based on their assets. Public confidence in the banking system returned.

Roosevelt then took steps to try to balance the budget. A deficit that would reach about four billion dollars by June 30, 1933, had been piled up, and this impeded recovery. By quick action Congress passed a bill reducing veterans' benefits and federal salaries, and otherwise cutting the costs of government. Time proved that it was impossible to hold the ground thus gained. Later Roosevelt distinguished between "normal" expenditures in which economy was continued, and "emergency" expenditures for relief, recovery, and defense in which government policy was generous.

VICE-PRESIDENTIAL CANDIDATE IN 1920



Roosevelt shakes hands with the Democratic presidential candidate James M. Cox of Ohio during their campaign against the Republican candidate, Warren G. Harding. *After the Democratic defeat, Roosevelt turned to the practise of law.*

Banks were rapidly reopening. With the swift ending of the banking crisis and the pledge of economy, people stopped hoarding money, prices of goods and securities rose slightly, and optimism began to return. At Roosevelt's bidding, Congress legalized the sale of beer, and it became plain that the prohibition era, with its scandalous lawlessness, was ending.

Meanwhile, congressional and executive leaders were conferring night and day on broader phases of legislation, and the "New Deal" was taking shape. One part was intended to promote recovery from the depression. Another part was designed to supply relief to the distressed while this recovery went on. A third part was to furnish certain permanent reforms,

ALPHABET OF THE CHIEF "NEW DEAL" AGENCIES

AAA (Agricultural Adjustment Agency), originally created 1933 and reconstituted in 1938 to bring farmers' share of nation's income back to level of 1909–14. Sought to provide an "ever-normal granary." During the second World War it led the drive for increased food production to meet war needs. Duties taken over in 1945 by Production and Marketing Administration of the Department of Agriculture.

CAB (Civil Aeronautics Board), created 1940 to succeed independent Civil Aeronautics Authority (1938). It establishes airways and landing fields; licenses aircraft and pilots; regulates rates; promotes air safety. In the Department of Commerce but functions independently.

CCC (Civilian Conservation Corps), created 1937 to succeed the agency known as Emergency Conservation Work (1933); provided employment and vocational training for needy young men through work in the conservation and development of natural resources. In the Federal Security Agency until abolished in 1942.

CCC (Commodity Credit Corporation), created 1933 to make loans to producers to finance the carrying and marketing of agricultural commodities. Division of the Department of Agriculture.

CSB (Central Statistical Board), created 1933 to coordinate federal and other statistical services. Duties absorbed by the Budget Bureau in 1939.

EHFA (Electric Home and Farm Authority), created 1935 to finance consumer purchases of electrical equipment in homes and on farms. Division of the Department of Commerce. Abolished 1942.

FAA (Federal Alcohol Administration), created 1935 to administer the federal liquor laws. Duties absorbed by the Bureau of Internal Revenue in 1940.

FCA (Farm Credit Administration), created 1933 to make long-term and short-term credit available to farmers and to farmers' coöperative marketing and purchasing organizations; assumed duties of Federal Farm Board (established 1929); system includes 12 districts, each with a federal land bank, intermediate credit bank, bank for coöperatives, and production credit corporation.

FCC (Federal Communications Commission), created 1934 to regulate interstate and foreign communication by telegraph, telephone, cable, and radio.

FCIC (Federal Crop Insurance Corporation), created 1938 to insure wheat producers against loss due to unavoidable causes and extended to growers of other crops. In the Department of Agriculture.

FDIC (Federal Deposit Insurance Corporation), created 1933 to insure the deposits of approved banks.

FERA (Federal Emergency Relief Administration), created 1933 to relieve the hardships caused by unemployment and drought; abolished 1938, and its work carried on by WPA until 1942.

FHA (Federal Housing Administration), created 1934 to encourage residential construction, repair, and modernization by insuring loans and mortgages. Division of Housing and Home Finance Agency.

FLA (Federal Loan Agency), created 1939 to direct all agencies lending federal funds, except those making agricultural loans. Abolished 1947, functions transferred to Reconstruction Finance Corporation (RFC).

FSA (Farm Security Administration), created 1937 to aid tenant farmers and carry on rehabilitation work of the Resettlement Administration. Duties taken over by Farmers Home Administration 1946.

FSA (Federal Security Agency), created 1939 to direct all agencies concerned with social and economic security, educational opportunity, and national health; includes Office of Education, Public Health Service, Food and Drug Administration, Children's Bureau, and Office of Vocational Rehabilitation.

FSCC (Federal Surplus Commodities Corporation), created 1935 to distribute surplus farm products to state relief agencies for the use of the needy. Merged into Agricultural Marketing Administration in 1942.

FWA (Federal Works Agency), created 1939 to coördinate all public construction. Abolished 1949, functions absorbed by General Services Administration.

HOLC (Home Owners' Loan Corporation), created 1933 to grant long-term mortgage loans on homes. Abolished 1947 by Housing and Home Finance Agency.

MLB (Maritime Labor Board), created 1938 to improve labor relations among seamen. Expired in 1942.

NEC (National Emergency Council), created 1933 to coördinate and make more efficient the work of the federal agencies. Abolished 1939 and functions transferred to Executive Office of the President.

NHA (National Housing Agency), created 1942 to consolidate all housing activities. Reorganized in 1947 as the Housing and Home Finance Agency.

NLRB (National Labor Relations Board), created 1935 to protect employees in their rights to self-organization and collective bargaining.

NRA (National Recovery Administration), created 1933 to draw up trade codes of fair competition; declared unconstitutional 1935.

NRPB (National Resources Planning Board), created 1939 to advise president on development of national resources; coöperated with state and regional planning boards. Abolished 1943.

NYA (National Youth Administration), created 1935 to furnish part-time employment for needy high-school and college students; to provide part-time employment on work projects for out-of-school youth; to provide vocational guidance. Transferred to Federal Security Agency 1939, and abolished 1943.

PWA (Federal Emergency Administration of Public Works, better known as Public Works Administration), created 1933 to reduce unemployment and restore purchasing power through construction and long-range planning of public works. Absorbed by FWA 1943.

RA (Resettlement Administration), created 1935 to administer rehabilitation and resettlement projects for the relief of farm areas. Abolished in 1937, and program completed by FSA.

REA (Rural Electrification Administration), created 1935 to introduce electric service into rural areas not now served. In the Department of Agriculture.

SEC (Securities and Exchange Commission), created 1934 to license and regulate stock exchanges and to control public utility holding companies.

SMA (Surplus Marketing Administration), created 1940 by merging the FSCC and the Division of Marketing and Marketing Agreements of the AAA. In 1942 merged in the Agricultural Marketing Administration.

SSB (Social Security Board), created 1935 to administer the federal old-age retirement funds. Functions absorbed, 1946, by Social Security Administration in Federal Security Agency.

TVA (Tennessee Valley Authority), created 1933 to operate government-owned properties at Muscle Shoals, Ala.; to develop water and power resources of the Tennessee River watershed; and to plan for the social and economic well-being of the valley.

USMC (United States Maritime Commission), created 1936 to develop a merchant marine to carry the domestic and foreign water-borne commerce of the United States on ships built, owned, and operated by United States citizens; succeeded United States Shipping Board and Merchant Fleet Corporation; was succeeded by Federal Maritime Board, 1950.

WPA (Works Progress Administration), created 1935 to relieve unemployment; later called Work Projects Administration. Abolished 1942.

especially in the management of banks and exchanges. Unity between Congress and the president was so complete, and public confidence in the Administration was so general, that it was possible to pass a complex series of measures before the 99-day special session ended. Never in United States history had so much far-reaching legislation been enacted in so short a time.

The relief legislation especially illustrated Roosevelt's resourcefulness. He had a bill passed establishing the Civilian Conservation Corps (CCC) which gave 250,000 young men subsistence and small wages

CAMPAIGN MANAGER FOR ALFRED E. SMITH

In 1924, when the governor of New York sought the Democratic presidential nomination, Roosevelt proposed his name to the convention. But Smith was rejected in favor of John W. Davis, who was defeated by Coolidge.

for work in the national forests and on other government properties. Another law set up the Federal Emergency Relief Administration (FERA), which made grants to the states for relief activity. Still another piece of legislation set up the Public Works Administration (PWA), which gave employment on roads, dams, public buildings, and other Federal projects.

The Triple-A and the Blue Eagle

The two most controversial of the early New Deal measures were efforts to raise the prices of farm products and manufactured goods while regulating activities of farmers, manufacturers, and all kinds of merchants. Both the Agricultural Adjustment Act and the National Industrial Recovery Act were sharp deviations from the old conservative path followed by the American government. To be sure, the Hoover administration had set up the Reconstruction Finance Corporation (RFC) to assist hard-pressed banks, railroads, and manufacturers by loans. It had thus interfered with "automatic" economic processes. But the Roosevelt administration now went much further.

First to pass was the Agricultural Adjustment Act (AAA). Its basic principle was the payment of benefits to agriculture in return for acceptance of government controls intended to cut down crop surpluses. Farmers growing wheat, cotton, corn, hops, rice, and other staples which went into foreign commerce were to place their operations under the direction of the secretary of agriculture He was to reduce the acreage given to staples which had been overproduced, diverting part of the land to soil-improving crops or other uses. The law also permitted the president to inflate the currency by free coinage of silver, printing more paper money, or reducing the gold content of the dollar. This was because many Western farmers believed that cheaper money would raise crop prices. Finally, the Act included provision for Federal loans to farmers at low interest rates. Altogether, it was the broadest and most drastic legislation ever passed in aid of agriculture. It set up a complex mechanism for controlling most of the six million American farms, whose owners had always been individualists to the core. The law made coöperation voluntary. Farmers who disliked the scheme might remain outside. But some of its features, and a strong farm sentiment against men getting "a free ride," tended to force all growers of export staples to accept the plan.

The Recovery Act was an even more radical innovation, affecting a still larger body of Americans. It set up a system of self-government by industry under government supervision. For many years various groups of manufacturers had been organizing "trade associations" which drew up codes of fair-trade practises, and tried to enforce them. One object of these codes was to stop cutthroat competition. Many people believed that one element in the depression was destructive business competition. The administration now worked out a scheme by which every branch of industry was to draft a fair-business code; such codes were to be amended if it was deemed necessary by the government; and when accepted they could be enforced in the federal courts. Under Section 7-A labor was to be protected by provisions in each code abolishing child labor, setting maximum hours of work, and fixing minimum rates of pay; and by special arrangements for collective bargaining. A powerful agency, the National Recovery Administration (NRA), was set up to administer the law. At its head Roosevelt placed a forceful executive famous for his picturesque language, Gen. Hugh S. Johnson.

From the outset many observers regarded this legislation as a dubious experiment. The trade associations with their new "codes" could go a long way toward fixing prices. It was sometimes hard to distinguish their activities from those of the monopolies or trusts which the government had long attacked. But for some months the country gave the experiment loyal support. A revivalistic enthusiasm, with newspaper advertisements, parades, and speechmaking, was worked up behind it. Roosevelt himself was full of faith. History, he said in signing the act June 16, 1933, would probably declare it "the most important

far-reaching legislation ever enacted by an American Congress."

Another spectacular recovery measure, which had a reform aspect, was the law setting up the Tennessee Valley Authority (TVA). Ever since the first World War, when a great plant for manufacturing nitrates had been erected at Muscle Shoals on the Tennessee River, a bitter quarrel had raged about the use of the Tennessee's water power. Important private interests tried to gain control of the Muscle Shoals plant. President Hoover favored private use. But Sen. George W. Norris of Nebraska fought with indomitable courage for the principle that the government should own and operate hydroelectric plants on the large rivers and sell the power cheaply. Roosevelt while governor had battled for the same doctrine. The new law set up a board to apply the principle to the Tennessee River. First Arthur Morgan, and then David Lilienthal, was the chief administrator of the TVA (*see* Tennessee Valley Authority).

Of the reform measures, two were especially interesting—the Glass-Steagall Banking Act, and the Securities Act. Most bankers were firmly convinced that many old abuses in their business must be stringently prohibited. One was the lending of huge sums of money for gambling in the stock market, something which had helped bring on the "bull" market" boom of 1928-29 and subsequent crash. The Federal Reserve Board was now given a stringent control of interest rates and loans. Another abuse had been the combination of commercial banking with investment banking. Many large commercial banks had set up investment branches which used depositors' money for speculating in risky securities. Now banks and investment houses were rigidly separated. In addition, the government guaranteed bank deposits up to $5,000, so that small depositors would never again grow panicky and withdraw their savings.

SETTING UP SOCIAL SECURITY

President Roosevelt is shown here as he signed the Social Security Bill, one of the most significant measures of his first administration.

Millions of Americans had lost a large part of their savings in 1930-33 through frauds and misrepresentation in the selling of stocks and bonds. The Securities Act of 1933, strengthened a year later, provided that full data upon all new security issues must be filed with a federal agency; that this data must be scrupulously accurate; and that all buyers of the securities must be furnished the information.

When Congress ended its 99-day special session, an amazing amount of legislation had been put upon the statute books. Time was to prove some of it good, some bad. Roosevelt said he would be satisfied if he were right 60 per cent of the time.

The World Economic Conference

Meanwhile a fiasco occurred in the international field. Roosevelt's program for meeting the depression had emphasized domestic rather than international measures. While it was a world-wide depression, he believed that the main problems had to be solved by the United States alone. One of his principal aims was to raise American price and wage levels. This required a delicate international adjustment, for if prices soared, foreign goods would flow into American markets. It seemed desirable to increase exports while keeping imports fairly low. Roosevelt, with advice from experts, decided that the best way to accomplish this was to devalue the dollar—that is, reduce the amount of gold which a dollar would buy. Britain and numerous other nations had already divorced their currency from gold. The United States took this step in March 1933, and the dollar soon dropped to 85 cents in terms of its old gold value.

But arrangements had been made for an international economic conference in London, to which the United States was pledged to send delegates. For a time Roosevelt thought it might accomplish great benefits. It should cut down trade barriers, he said, and stabilize world currencies. It "must succeed. The future of the world demands it." The American delegation headed by Secretary Hull was sent to England. For a time the conference seemed likely to cut all tariffs, and to stabilize the dollar, pound, and franc at about their existing levels. But Roosevelt suddenly decided that the dollar had not yet dropped to its proper level. If it did not go lower, he thought the domestic program of raising prices would be endangered. He therefore startled the conference by his famous "bombshell" message of July 3, which rejected the stabilization program.

Though Secretary Hull tried to obtain some last-minute results from the conference, it broke up in failure. Nothing was done except to make some minor arrangements to deal with the world surpluses of wheat and silver. The President thought that international agreement was less important than future action to reduce the gold value of the dollar. He took such action later in the year, devaluing the dollar to about three-fifths its former gold content. This was expected to bring about a further price rise, but failed to do so. In the eyes of most Europeans and

many Americans, he had ruined a promising effort to aid in world recovery.

Tests of the NRA and AAA

The years 1934-35 witnessed dramatic tests of New Deal measures. Throughout the summer and fall of 1933 various industries drafted NRA codes under General Johnson's direction. In all, 557 basic codes were drawn up. Of these, 441 had provisions for fixing prices. All the codes forbade child labor, and many raised wages and lowered hours. Every effort was made to bring about increased employment under code agreements and some progress was made. But public opinion grew more and more hostile.

There were several reasons for this. One was that the codes which fixed prices and limited production seemed to raise the cost of living unduly. Goods labeled with the NRA symbol, the blue eagle, were too expensive. Consumers felt sure that the NRA system did not give them sufficient protection. Another reason was that the system injured small businesses. Their production costs were usually higher than in big business units, and some of the new regulations increased these costs. Still another reason was that many codes proved too complicated. It took expert lawyers to interpret them. Businessmen became confused, and when they were reprimanded or arrested, they were indignant. Many people feared that the NRA system would place them under permanent government regulation of an arbitrary sort. Labor leaders asserted that the minimum wages fixed in the codes were usually maximum wages. They also complained that the big corporations evaded the requirement for collective bargaining by forming "company unions" which had no real independence.

As the attack grew heavier, efforts were made to meet the objections. A board was set up under Clarence Darrow to review the NRA and to make a report. Many small businesses were exempted from its regulations. General Johnson resigned, and his place was taken by Donald Richberg. But still the NRA continued to work unsatisfactorily, and general relief was felt when the Supreme Court on May 27, 1935, unanimously declared the Recovery Act unconstitutional.

The AAA under Secretary Wallace had taken effective steps to reduce production of crops where surpluses existed, and to raise farm income. Enforcement was wisely left to local boards of farmers and to county farm-bureau officials. Within a short time the program enlisted millions of farmers. In the South alone, 1,800,000 cotton growers united to take more than 10,000,000 acres out of cotton production. In the Northwest a program to reduce wheat acreage was equally successful. Altogether 35,700,000 acres were taken out of surplus-staple production in 1934, and 30,300,000 in 1935. Thanks to this and other factors, the cash income of farmers rose sharply. It had been \$4,500,000,000 in 1932, and reached \$6,800,000,000 in 1935.

Though a majority of farmers approved the AAA, it was sharply criticized by others. Many attacked it as a plan to create scarcity. The idea that cotton should be deliberately plowed under and baby pigs killed seemed outrageous when some people were ill-clad and hungry. Other critics pointed out that the chief AAA benefits went to big farms. The hard lot of tenant farmers and hired men was not improved. It was also objected that any rise in cotton, wheat, and pork prices meant a loss of foreign markets for American produce, for Europe could buy only at low levels.

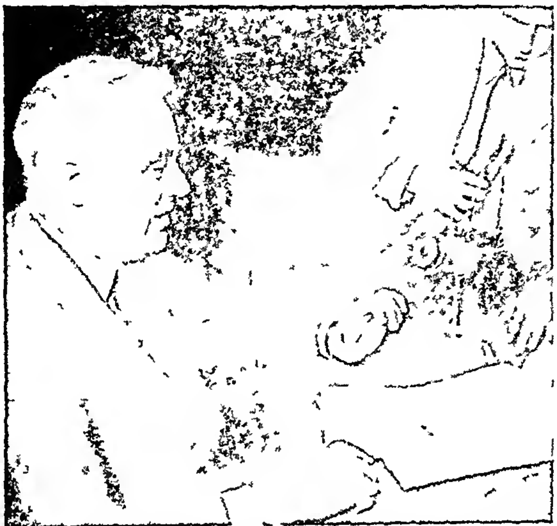
Anticipating the Supreme Court decision which on Jan. 6, 1936, annulled the Agricultural Adjustment Act, the Administration had a substitute ready. The Soil Conservation and Domestic Allotment Act signed March 1, 1936, preserved the old system of Federal payments to farmers and gave it a new basis. They were to be paid for cooperating with a national program to save and improve the soil; that is, for checking erosion, for growing clover, alfalfa, soy beans, and other nitrogen-building crops in place of corn and wheat, and for using fertilizers. The new system was constitutional, and paid for itself in the values it added to the farms. Later on, in 1938, a more complex law was enacted, which included Secretary Wallace's proposals for an "ever-normal granary." That is, moderate surpluses in staple crops were to be stored as reserves to meet crop failures in bad years.

ONE OF THE MANY FEDERAL HOUSING PROJECTS

To provide healthful dwelling places for people with small incomes, the Public Works Administration and the United States Housing Authority helped to build many group housing "communities" such as this apartment project in Cleveland.

The country had accepted the idea that the government should guarantee farmers an adequate income. It had also accepted some of the principles that had led to creating the NRA. A separate law (the Wagner National Labor Relations Act) became effective July 5, 1935, to guarantee labor the right of collective bargaining which it had been granted under NRA. A rapid growth of unions ensued, and became one of the most spectacular features of the New Deal years. In 1933 the official membership of the American Federation of Labor, led by William Green, had declined to 2,317,500. Now it increased rapidly; a powerful new body appeared under John L. Lewis, first called the Committee for Industrial Organization and later the Congress of Industrial Organizations (C.I.O.). By 1943 unions had an enrollment of nearly 12,000,000. (*See also* Labor.)

THE FIRST PEACETIME CONSCRIPTION



On Sept. 16, 1940, President Roosevelt signed the Selective Training and Service Act, which ordered the drafting of men into the Army and Navy. The actual drafting of men began the following November.

Social Security Measures

By 1935 Roosevelt was prepared to bring the second phase of his New Deal before the country: a series of measures for social security. In his annual message as the year opened he declared that the day of great private accumulations of wealth had ended. Instead, wealth must be better distributed; every citizen must be guaranteed "a proper security, a reasonable leisure, and a decent living throughout life." Unemployment, poverty, and distress were still rife, for though the depression had lessened, it had not ended. Radical agitators were gaining a following. The Townsend Plan for paying every aged person $200 a month and Huey Long's Share-the-Wealth plan showed that great discontent existed. Roosevelt felt it was time for the United States to follow Great Britain and other countries in providing insurance for unemployment and old age.

The Social Security Act, which Roosevelt signed in August 1935, was one great step in the program. Both the unemployed and the aged were to be looked after by a combination of federal and state action. National taxes were to be laid on payrolls, running up to a maximum of three per cent in 1939, so as to build up an unemployment-insurance fund; and states which had suitable insurance systems could administer most of the payments. By the middle of 1938, all states had adopted the requisite laws, and about 27-000,000 persons were guaranteed unemployment benefits. The national government was also to give assistance to the states in paying pensions to aged people. A separate federal annuity system, based on contributions by wage earners, was to give every contributor a pension at the age of 65, proportionate to the money that person had paid in. This annuity plan covered about 46,000,000 people. (*See also* Social Security.)

Other "welfare" measures of great social importance related to slum clearance and the provision of decent housing, which the Roosevelt Administration encouraged by generous loans; to farm tenancy, an evil which it attacked by advancing money to sharecroppers, farm laborers, and others who wanted to become independent owners; and to the electrification of farms, which was assisted by setting up a Rural Electrification Administration and by loans. Help continued to be given to the needy, chiefly in work relief; part of it through the Works Progress Administration (WPA) and part through the Public Works Administration (PWA), both of which did an immense variety of construction work. A National Youth Administration gave part-time work, at from $6 to $15 a month, to high school and college students.

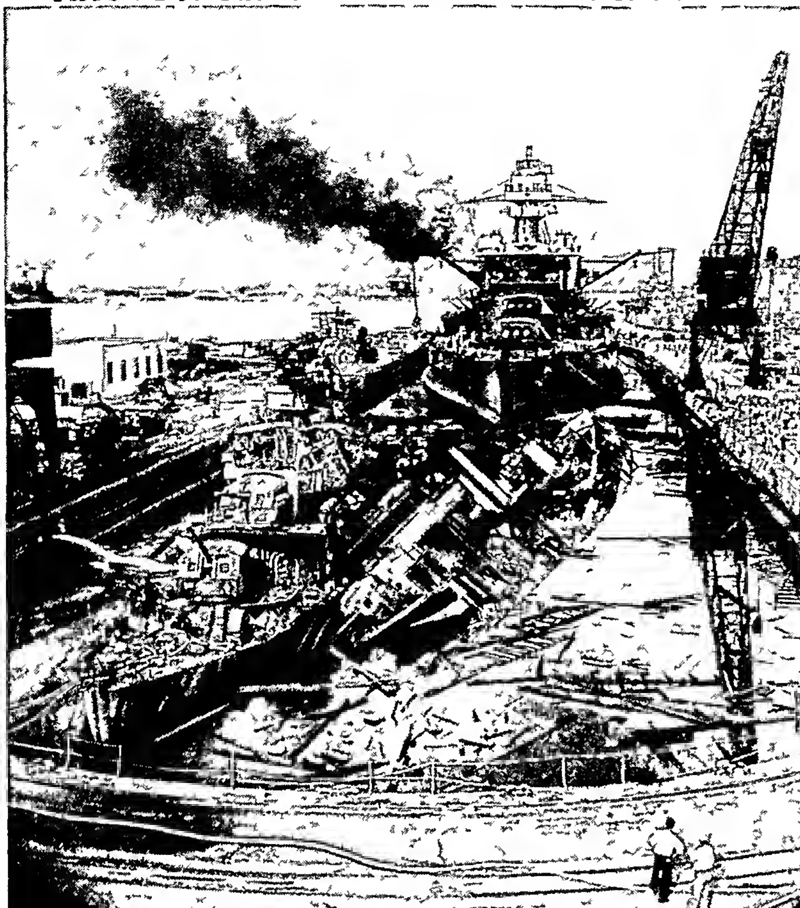
Re-election and the Supreme Court Fight

In 1936 Roosevelt entered his contest for re-election with most of big business distinctly against him, but with most farmers, workmen, and small tradesmen on his side. His opponent, Alfred M. Landon of Kansas, was supported by about two-thirds of the nation's larger newspapers. Roosevelt's backers spent about $5,200-000; Landon's backers about $9,000,000. Yet the result could be predicted long in advance. It was a Roosevelt landslide, in which the president carried 46 states, leaving Landon only Vermont and Maine, and won a popular plurality of 11,070,000 votes,

With this emphatic endorsement of the New Deal, Roosevelt decided to challenge the Supreme Court, which had done much to block his measures. It had abolished the AAA and NRA; it had annulled the Guffey-Snyder Coal Stabilization Act, designed to help the bituminous coal industry; it had invalidated the New York Minimum Wage Act. A half dozen important New Deal measures still were up for decision. If its attitude did not change, it seemed impossible to make his program effective. Of the nine justices, six were over the permissive retirement age of 70. Four were extremely conservative, and they could usually count on a fifth to join them in a majority decision.

Despite the public veneration for the court, Roosevelt resolved to attack it. In his second inaugural he declared that radical social legislation was still needed, for "I see one-third of a nation ill housed, ill clad and ill nourished," and that the Constitution "did not make our democracy impotent." Swift action followed. On Feb. 5, 1937, he sent Congress a message *proposing to reorganize the court.* To match every

THIS PLUNGED THE UNITED STATES INTO WAR



Here at Pearl Harbor, Hawaii, on Dec. 7, 1941, the Japanese struck the surprise blow that made the United States a belligerent in the second World War. In this drydock lie two wrecked destroyers and the slightly damaged battleship *Pennsylvania*.

judge who failed to retire at 70, the president asked to be allowed to appoint a new judge until the court had a total of 15.

The plan produced great excitement. The Senate Judiciary Committee condemned the scheme as "needless, futile, and utterly dangerous." Some state legislatures passed hostile resolutions. Not only all conservatives, but several liberal senators attacked the court-reorganization bill as likely to result in presidential control of the court. Roosevelt appealed to the country in a "fireside chat." But the nation remained dubious, and even his friend Governor Lehman of New York opposed the change. When Sen. Joseph T. Robinson, who had the measure in charge, suddenly died, hope for its passage vanished.

But meanwhile Roosevelt had won a victory in the court itself. While the six months' struggle was raging in Congress, the court began to sustain one New Deal law after another. Among them were the vitally important Wagner Labor Relations Act, and a Washington State Minimum Wage Act which was essentially like the New York law that the court had annulled. It was clear that Justice Owen J. Roberts had swung to the liberal side, and left the four conservatives in a minority. One conservative, Justice Van Devanter, soon resigned. Others shortly followed, and were replaced by men of Roosevelt's choice. Swiftly it became sufficiently liberal in its philosophy to suit the president.

Roosevelt continued to press his New Deal measures. At his request Congress early in 1938 passed a Federal Crop Insurance bill to insure wheat farmers against losses from hail, drought, tornadoes, floods, and the like. The TVA was steadily supported in its expansion. Roosevelt encouraged the building of other dams, notably the Norris Dam on the Tennessee and the Bonneville and Grand Coulee on the Columbia. In 1938 the Fair Labor Standards Act became law. Minimum wages in all industries engaged in interstate commerce were to begin at 25 cents an hour, and in seven years rise to 40 cents; the maximum work-week was to begin at 44 hours, and in two years become 40 hours. This placed "a floor under wages and a ceiling over hours." The Social Security Act was strengthened, so that by the spring of 1941 nearly 2,200,000 persons not covered by old-age insurance were receiving federal and state assistance.

Trade Treaties—*Latin America*

In foreign affairs Roosevelt was heir to the traditions established by Wilson. His guiding principles were the promotion of world peace by international arrangements; the maintenance of fraternal cordiality with Latin American nations and the British Commonwealth; and the encouragement of freer international trade. The economic nationalism of his first year in office was abandoned. Together with Secretary Hull, he pressed for tariff reductions throughout the globe.

The chief agency used to effect this was the Reciprocal Trade Agreements Act which Congress passed in 1934. This authorized the president to make agreements with other nations for the mutual reduction of tariffs, running up to 50 per cent of the United States schedules. The reduced rates were to be extended automatically to almost all other nations. Such agreements did not require Senate ratification. This law was extended in 1937, in 1940, and in 1943. Under it, treaties were negotiated with a long list of nations. For a dozen years after the first World War the United States had been a leader in raising tariffs. Now it became a leader in lowering them.

The "good neighbor" policy toward Latin America, announced in Roosevelt's first inaugural address, had several aspects. It meant that the United States gave up its old single-handed enforcement of the Mon-

roe Doctrine, wishing instead to rely upon enforcement by all American nations. It meant that it would no longer meddle in the affairs of Latin American nations; Roosevelt said in 1933 that "the definite policy of the United States from now on is one opposed to armed intervention." Even when Cuba became the scene of serious disorders under the dictator Machado, the United States did not land troops. Instead, in 1934 the United States gave up the Platt Amendment, under which we had a right to interfere in Cuba. That same year our marines were evacuated from Haiti. Nor did the government exert undue pressure in behalf of American investors in Latin-American lands. Mexico in 1938 seized all the oil properties of American companies, and failed to make adequate payment, but the Roosevelt Administration did not go beyond mild and tactful measures of protest.

In every way Roosevelt tried to win the confidence of Latin America. He made the long trip to Buenos Aires in 1936 to open a special Inter-American Conference with a cordial speech. Canada also was treated with marked friendliness. Roosevelt favored developing a Great Lakes-St. Lawrence waterway to the sea; and in 1938 he made a speech in Ontario in which he pledged American aid if Canada were ever attacked. The result was that when the war clouds grew thick, nearly all the Western Hemisphere was a unit behind Roosevelt's main policies.

Troubles in the Far East

For 12 years Roosevelt labored consistently to awaken the United States to the perils of aggression by nations whose leaders believed they could dominate the world. He tried to halt Japan, Italy, and Germany in their brutal measures, and he gave encouragement to Britain, France, and other democracies.

It was Japan which first aroused grave apprehension. In 1931 it had overrun Manchuria, and in 1932 had captured Shanghai, butchering thousands of Chinese. President Hoover had refused to recognize its puppet state of Manchukuo, and protested against its efforts to close the Open Door for Chinese trade. When fighting began again in North China and at Shanghai and Nanking in 1937, Roosevelt was deeply troubled. The Japanese aggression, the bloody fighting at the same time in Spain, where a civil war brought in Germans, Italians, and Russians, and the warlike threats of Hitler and Mussolini, made him feel that "international lawlessness" was in the saddle.

It seemed clear that Japan, which claimed the right to act alone for "peace and order in East Asia," was intent on conquering all China. The United States had investments and property there worth a quarter-billion dollars, and valued Chinese trade. Above all, it had taken a special interest in education, missionary work, and the growth of democracy in China. Making one of his most important speeches at Chicago on Oct. 5, 1937, Roosevelt declared that the United States would certainly suffer greatly if another world war broke out. He proposed that the nations responsible for "international anarchy" should be quarantined. The peace, freedom, and security of nine-tenths of the world, he said, were being jeopardized by the remaining ten per cent. Surely this 90 per cent which upheld peace and moral standards "can and must find some way to make their will prevail."

The response to this speech disappointed Roosevelt, for polls and press comment showed the country adverse to positive action. Some two months later Japanese aviators bombed and sank the American gunboat *Panay* in Chinese waters, with two killed, and sank three American oil tankers. Japan promptly apologized and the country remained calm.

To Roosevelt's chagrin, American isolationism reached a peak in 1937-38. Congress passed a "permanent" neutrality law in 1937 to replace a temporary measure enacted two years earlier. It was an attempt to safeguard national peace and safety if a conflict broke out abroad. When the president proclaimed that a state of war existed, no loans or credits were to be granted either side. No arms were to be exported to any belligerent. American citizens were not to travel on the ships of warring countries. Even raw materials could not be shipped to a belligerent except on a "cash and carry" basis; that is, they must be paid for in advance, and carried in foreign vessels. Roosevelt and Hull objected to this law because, in a war of aggression, we would be helpless to give aid to the victim.

The best that Roosevelt could do was build up our defenses. Under his prodding, Congress in May 1938 passed a billion-dollar appropriation for construction of a Navy strong enough to protect both coasts against simultaneous attack.

The March of the Axis

While Congress was passing its neutrality legislation, the leaders of Germany, Italy, and Japan were in fact planning the destruction of all democracies. Mussolini had given Italy a dynamic Fascism which looked for foreign conquest. Hitler, coming to power in 1933, had set up a Nazi régime partly modeled on Italian Fascism, but far more ruthless and powerful. As Germany swiftly rearmed, all Europe was filled with dread. In their systematic use of force, the Nazis and Fascists, who formed what they called the Axis, counted on aid from Japan, now completely controlled by naval and military leaders.

Hitler and his Nazi forces in March 1938 seized Austria and incorporated that country in a greater Germany. The next on the list was Czechoslovakia. Taking advantage of the fact that one part of that sturdy democracy, the Sudetenland, was predominantly German, Hitler began a campaign of threats and intrigues. It rose to a climax late in September 1938, when he stood on the verge of armed conquest. His demands were so harsh that compromise was impossible. His armies were ready to march. A general European war, Britain and France aiding Czechoslovakia and Italy assisting Germany, seemed imminent. On Sept. 26 Roosevelt cabled every nation an earnest plea for peace. This failed, and he thereupon sent Mussolini and Hitler desperate personal messages. When the Munich conference resulted in the surrender of the

MEETING OF ALLIED LEADERS IN WASHINGTON

President Roosevelt and British Prime Minister Churchill conversing between sessions of the Anglo-American strategy conferences in May 1943 This was the fourth meeting of the two leaders to talk over moves against the Axis.

Sudetenland to Hitler, the American people began to realize the fearful peril in which all democracies stood. Hitler had promised to respect the integrity of what was left of Czechoslovakia. But he tore up that promise in March 1939, sending his armies smashing through the country. Hull, with Roosevelt's backing, protested against the "wanton lawlessness" of this use of "arbitrary force." When Mussolini immediately seized Albania, Roosevelt sent the two dictators notes asking for pledges that they would attack no more neighbors. "Heads of great governments in this hour," he wrote, "are literally responsible for the fate of humanity in the coming years"; adding that "history will hold them accountable for the lives and the happiness of all." Nothing but insulting evasion resulted.

The European crisis now entered its final acute stage. Hitler, demanding that Poland return Danzig to Germany and make concessions on the Polish Corridor, was threatening the Poles with complete destruction. Late in August, Germany and Russia reached an agreement that gave the Nazis a free hand. Roosevelt made another plea for peace, sending personal messages to the king of Italy, the president of Poland, and Hitler. But the German dictator was determined on a war of conquest. Without any personal reply to Roosevelt, on Sept. 1, 1939, he ordered his armies to strike Poland. France and Britain entered the conflict, and the most terrible war of history was under way.

Neutrality and Defense, 1939–41

For a little more than two years, the United States stood nominally neutral. Actually its sympathies were with Britain, France, and Poland from the beginning, and it soon gave the democracies substantial aid. Congress, which Roosevelt summoned in special session while Hitler was overrunning Poland, met his wishes by repealing the arms embargo (Nov. 4, 1939). Shipments of shells, guns, and aircraft at once went forward to the British and French. Meanwhile Roosevelt took steps to rally Latin America for united action. Foreign ministers of the various republics, meeting at Panama just after the outbreak of war, agreed on common measures of hemisphere protection.

With the world on fire, preparations for national defense now had a desperate urgency. In the first days of 1940 Roosevelt asked Congress for a defense appropriation of $1,800,000,000. But this was only a beginning. April saw the Nazis seize Norway and Denmark. In May 1940, Hitler's armies entered Holland and Belgium, swept over those countries, crushed the French resistance, and forced the British to withdraw from the Continent. Addressing Congress on May 6, 1940, Roosevelt pointed out the horrible destructiveness of modern war, declared that no nation could be too strong, and demanded means of stopping any aggressor "before he can establish strong bases within the territory of American vital interests." He asked for at least 50,000 airplanes, large additions to the navy, and $1,000,000,000 for a larger army. On May 31 as the Nazi sweep continued, he called for another $1,000,000,000.

PLANNING FAR-EASTERN STRATEGY

At Cairo, Egypt, in 1943, Roosevelt met with Chiang Kai-shek, Churchill, and Madame Chiang to discuss plans and determine the strategy for beating the Japanese aggressors into unconditional surrender.

Congress was now fully awake to its responsibilities. It not only voted these appropriations, but on July 10 gave the President another $5,000,000,000 that he requested. That summer, for the first time, the country adopted universal peacetime conscription, and began training a million men. It joined Canada

in setting up a Joint Board of Defense, which meant a military alliance. It gave hard-pressed Britain 50 destroyers, and in return received leases for a series of Atlantic naval bases extending from Newfoundland to British Guiana. This, said Roosevelt, was the most momentous step in our national defense since the Louisiana Purchase. A Latin-American conference at Havana in July resulted in full agreement for collective defense of the New World.

This was the summer of a presidential campaign, with Roosevelt pitted against Wendell Willkie, the Republican nominee. Ordinarily the traditional opposition to a third term might have defeated Roosevelt. But to many the crisis seemed to demand the retention of an experienced and tested leader. Willkie fought many of Roosevelt's domestic policies. But he performed a notable service for national unity when he refused to play politics with foreign affairs. Boldly approving the destroyer arrangement, he even urged increased aid to Britain. Willkie also accepted many of the New Deal reforms, merely advocating improved methods in carrying them out. Though he was a leader of unusual vision and courage, the country refused the risks of a change. Roosevelt carried the election with 55 per cent of the popular vote, and 449 electoral votes against 82 for Willkie.

The Arsenal of Democracy

Six weeks after the election, Roosevelt made a radio address warning the country that if Britain were defeated, the Axis would dominate the world and America would live at the point of a gun. The emergency was as serious as war itself, he said. "We must be the great arsenal of democracy." Already he had one of his greatest measures in view—Lend-Lease.

The Lend-Lease Act, which became law after a bitter Senate debate on March 11, 1941, was a measure for helping Britain and China hold Germany and Japan at bay. It authorized the president to "sell, transfer title to, exchange, lease, lend, or otherwise dispose of" any defensive article to any nation whose defense he deemed vital to American security. These articles included not only weapons, but machines, raw materials, and even repair services. The law permitted the Allied nations to send warships to the United States for refitting, and to train air crews in America. It encouraged the exchange of military information. In short, it made the United States an active auxiliary of all enemies of the three Axis nations. A fortnight after the bill passed, Congress appropriated $7,000,000,000 as a first installment to support lend-lease. By this law the United States really became the arsenal of democracy. Its aid came in the nick of time for hard-pressed Britain and for Russia, which Hitler invaded in June 1941. Ships, guns, airplanes, shells, and small arms, along with food, clothing, and metals, flowed overseas in a steady stream. To make sure that lend-lease goods would be delivered, American warships began patrolling North Atlantic sea lanes, and American forces were landed in Greenland and Iceland. Finally, after German submarines had attacked various ships, the United States closed all German consulates, and ordered its Atlantic patrol vessels to shoot on sight.

Roosevelt saw the importance of moral as well as physical preparation for war. In January 1941 he outlined the four freedoms essential to civilization: freedom of speech, freedom from want, freedom of religion, and freedom from fear. A still more striking formulation of war aims followed. Meeting Prime Minister Winston Churchill in the North Atlantic on August 14, he and the British leader agreed upon the Atlantic Charter, a statement of principles on which they founded their "hopes for a better world."

DISCUSSING THE WAR IN THE PACIFIC

In 1944, Roosevelt went to the Pacific to observe the progress of the war in that area. Here he confers on problems of strategy with Gen. Douglas MacArthur (left) and Adm. Chester W. Nimitz.

The charter was a restatement in a simpler language of the most vital of Wilson's Fourteen Points. It included a declaration against territorial aggrandizement; another against territorial changes not approved by the people involved; a statement of the right of populations to choose their own form of government; and demands for freedom of the seas, free access to trade and raw materials, economic cooperation, and the abandonment of force in international affairs.

Pearl Harbor and the Clash of Arms

As long as the history of the nation is read, Pearl Harbor will be recalled with Concord and Fort Sumter.

The nation seemed drifting into war with Germany on the Atlantic. Hostile shots had been fired, and ships sunk. Most eyes were fastened on the European scene. But in the Pacific a grim drama had been unfolding itself, and now suddenly reached its climax. The Japanese, confident that Germany would overthrow Russia and Britain, had determined on a swift completion of their Asiatic conquests. In November 1941, while the British were holding off swarms of Nazi bombers and the Russians were fighting desperately to save Leningrad and Moscow, the Japanese seized part of French Indo-China, and planted air bases in Siam. They were threatening Burma, the Dutch East Indies, and the Philippines.

As the United States protested, a special Japanese mission arrived in Washington on November 14 to open negotiations. It proposed that America recognize the Japanese advances in southeastern Asia and resume full commercial relations. Secretary Hull refused, and proposed that in return for commercial concessions, Japan withdraw from Indo-China and China. A complete deadlock was reached. Japanese warships and air forces showed great activity in Asiatic waters. Premier Tojo on November 21 informed the Japanese Diet that the situation was extremely serious. Roosevelt then, on December 6, made a direct appeal to the emperor. Next day, Sunday, December 7, at 7:50 A.M. Honolulu time, Japanese forces made their surprise attack upon Pearl Harbor.

DEMOCRATIC CAMPAIGN LEADERS

Vice-President Wallace confers with Sidney Hillman about the 1944 presidential campaign. The congressional elections of 1942 had shown strong Republican gains. The skillfully organized Political Action Committee of the CIO, headed by Hillman, helped to turn the tide back to Roosevelt.

Germany and Italy at once opened hostilities, and the titanic conflict which now began demanded far greater exertions than America had ever before made. For a full year the fortunes of war hung in close balance. The American Navy had been heavily crippled at Pearl Harbor. The Japanese, in full control of the western Pacific, overran the Philippines, British Malaya, and the Dutch islands, threatening India and Australia. Meanwhile, German submarines sank hundreds of ships off the Atlantic coast of the United States. The British armies in North Africa were thrown back to the gates of Cairo and seemed likely to lose the Suez Canal. The Russian armies, losing vast areas, were forced to fight under the very walls of Moscow and Stalingrad.

Early in 1942 Roosevelt called upon industry to produce implements of war on a scale never before approached: 185,000 airplanes, 120,000 tanks, and 18,000,000 deadweight tons of shipping within two years. Steps were taken to build up the armed forces to a total of 11,100,000 by midsummer of 1944. The navy was expanded until it was not only the greatest in the world, but greater than all other navies combined. Industries mobilized for war tasks until their production far exceeded all records, and the number of persons gainfully employed or in uniform surpassed 65,000,000. Every activity of the nation was put into relation with the winning of the war.

Roosevelt as War Leader

"We are now in the midst of a war, not for conquest, not for vengeance, but for a world in which this nation, and all that this nation represents, will be safe for our children." So Roosevelt told the country in his war message of Dec. 9, 1941. In the years which followed both domestic policy and foreign policy were mainly guided by the President. Congress passed the First and Second War Powers Acts, which with other legislation placed the fullest authority in his hands. He was given almost absolute power over agriculture, manufacturing, labor, prices, wages, transportation, and the allotment of raw materials. These powers, by a series of executive orders, he deputed to appropriate persons, boards, or departments. A complex body of war agencies was set up, and passed through many changes, shifting and expanding as circumstances required. They brought nearly every activity of the country under government direction.

As in 1861 and 1917, the President's personal leadership was all-important. In a very real sense Roosevelt was Commander-in-Chief of the Army and Navy. All the main decisions were his responsibility. With the aid of Gen. George Marshall, chief of staff for the army, and Adm. Ernest J. King, chief of staff for the navy, he blocked out the broad lines of strategy. Late in December 1941, and again in June 1942, Prime Minister Winston Churchill of Great Britain arrived for long conferences that set the pattern for complete unity of American and British effort. The President chose the heads of the great new war agencies, and, if any failed, replaced them—though sometimes too tardily. He strove to compose difficulties between important government officers, as when in 1943 he had to deal with a bitter quarrel between Vice-President Henry Wallace, who was also chairman of the Board of Economic Warfare, and Secretary of Commerce Jesse H. Jones, who was also head of the Reconstruction Finance Corporation. This ended only when he relieved both of duties in the foreign economic field. Roosevelt had to keep a jealous and sometimes irritable Congress in hand. He also had to bolster the nation's morale during the dark days of early military reverses.

The President made some poor appointments. He never gave the hastily improvised war administration real symmetry or complete efficiency. His alleged favoritism to labor, and especially the C.I.O., inspired a congressional revolt in 1943. But on the whole he handled his task with superb confidence and ability.

The first necessity was to raise adequate forces for the army and navy. All men from 18 to 64 years of age were required to register, and those of 20 to 44 (later 18 to 38) were made subject to service in the armed forces.

Work of the Great War Agencies

Though mistakes were made and much waste was unavoidable, most of the special war agencies displayed great efficiency. The War Production Board, with Donald M. Nelson (later J. A. Krug) as chairman, obtained materials, allocated them to factories, placed contracts, and regulated output. The War Manpower Commission under Paul V. McNutt took steps to see that agriculture, mining, manufacturing, and all other essential activities got a fair share of manpower and used it effectively. The National War Labor Board, of which William H. Davis was chairman, had power to determine labor disputes in all industries, and passed upon all wage increases. The Office of Price Administration, one of the most vital of all agencies, headed first by Leon Henderson and later by Chester Bowles, had responsibility for keeping prices stable, controlling rents, rationing automobiles, gasoline, foods, and many other "short" commodities, and in general preventing a disastrous inflation.

The War Shipping Administration under Rear-Admiral Emory S. Land controlled all ocean-going merchant vessels to insure their effective use. The Office of Lend-Lease Administration, long under E. R. Stettinius, Jr., facilitated the flow of lend-lease materials to nations requiring them, and helped manage reverse lend-lease shipments from various countries. All transportation, by air, road, rail, and coastwise shipping, was supervised by the Office of Defense Transportation, with Joseph B. Eastman as director. The Office of War Information, of which Elmer Davis was made head, coördinated the flow of war news from all federal departments, and used the press, radio, and motion pictures to distribute information on the conflict to the American people and the world at large. It also helped to conduct "psychological warfare" against enemy peoples to undermine their morale.

An important set of agencies, in which Roosevelt took special interest, coördinated the war activities of the United States, Canada, and Great Britain. The Combined Chiefs of Staff was set up in December 1941, after a conference in which Churchill and the heads of the British army, navy, and air forces met Roosevelt and the chief American staff officers. This agency brought about what Gen. George Marshall termed "the most complete unification of military effort ever achieved by two Allied nations." It directed the strategic disposition of all forces of America and Britain, allocated manpower and munitions, controlled communications and military intelligence, and provided joint administration of captured areas. A Combined Production and Resources Board saw to it that the industrial resources of Britain, Canada, and the United States were managed as a unit. A Combined Raw Materials Board and Combined Food Board assisted in pooling needed supplies of all kinds.

Many other agencies aided in the war effort. James F. Byrnes directed an Office of Economic Stabilization which dealt with the many dislocations and shocks caused by the conflict. An Office of Civilian Defense under James M. Landis labored to maintain morale and give millions of civilians an opportunity for constructive war work. In order to cement our friendly relations with other American republics, the Office of Coördinator of Inter-American Affairs was created under Nelson A. Rockefeller. One of the most important of all the agencies was the Office of Scientific Research and Development. With Dr. Vannevar Bush as director, it labored on scientific problems that remained secret until the atomic bomb appeared and the war was over.

National unity was far more complete in the second World War than in any previous conflict. This was partly because the brutality of the Axis Powers had deeply shocked and offended Americans. It was partly because the war had opened with a treacherous attack upon the United States. It was partly because of the threat to the very existence of the republic. But it was also because the people, who realized the failure after the first World War, were resolved to build a permanent structure for peace and progress. "We owe it to our posterity, we owe it to our heritage of freedom, we owe it to our God," said Roosevelt on Oct. 5, 1944, "to devote the rest of our lives and all our capabilities to the building of a solid, durable structure of world peace."

Production Feats of the War

The peak mobilization of the United States for armed service reached about 14,000,000 men and women. To equip and supply these huge forces, to assist in equipping the nearly 50,000,000 persons in the armed forces of Russia, the British Empire, China, and our other allies, and to maintain the civilian economy, feats of production never before approached were necessary.

To finance the war effort, unprecedented sums were raised by taxation. The whole cost of the conflict came to nearly 300 billion dollars. War loans raised a considerable part of the money needed. By the middle of 1944 the national debt stood at almost 200 billions. Taxation meanwhile had become far heavier than Americans would have once considered possible. By 1944 between 40 and 50 million Americans were paying income taxes. In the fiscal year which ended on June 30, 1944, the country raised almost \$20,000,000,000 by direct taxes on individuals, more than \$14,000,000,000 by direct taxes on corporations, and \$5,000,000,000 by excise taxes.

The managers of American industry made good their reputation for getting things done. Huge new munitions factories were hurriedly built in all parts

ROOSEVELT'S HOME AT HYDE PARK, N.Y.

The Roosevelt family estate on the east side of the Hudson River was a welcome retreat whenever the President wished to pause briefly in his labors as the nation's chief executive.

of the country. Great shipyards appeared as by magic on the Atlantic, the Pacific, the Gulf, and even the Great Lakes. Automobile plants were converted to making airplanes, tanks, "jeeps," and antiaircraft guns. Whole new industries, such as those that made magnesium and synthetic rubber, sprang into lusty life. The steel mills roared night and day, reaching an annual output of nearly a hundred million tons. The aluminum industry doubled in size. Labor toiled with a will. Superintendents and engineers prided themselves on radical new methods that increased production miraculously. And in the background the farmers, with their boys gone to war and the supply of implements limited, worked to raise record crops. In 1941 they grew more food than ever before; in 1942 they raised the mark again; in 1943 they increased it once more. In fact, the 1943 food production was one-third larger than the average of the five years before the war began in Europe

"We must wage the coming battle for America and civilization on a scale worthy of the way we have unitedly waged the battles against tyranny and reaction," said Roosevelt in Boston in 1944. By the middle of that year the synthetic rubber output of the United States and Canada had been brought up to a rate of 850,000 long tons annually, which was more than the natural rubber imported in peacetime. Tremendous as was the demand for steel, the mills kept pace with it. Tanks were produced in such quantities that they had to be cut back. Their design left much to be desired till near the end of the war, but their numbers were generally adequate.

Airplanes were essential to victory, and the United States prided itself on the efficiency of both its fighters and bombers. Some types, notably the Liberators, Catalinas, Flying Fortresses, and Super-Fortresses, became famous throughout the world. The aircraft industry expanded so rapidly that by 1944, when it employed nearly two and a half million workers, it was the largest single manufacturing industry in the world. Roosevelt had asked for an ultimate total of ten thousand aircraft a month. That goal was almost achieved in 1944, when the output exceeded a hundred thousand planes.

A RARE MOMENT OF RELAXATION

At ease by the fireplace, the President rests with his wife (left) and mother, Mrs. James Roosevelt. From this room Roosevelt frequently addressed the nation in informal radio talks that came to be known as "fireside chats."

Equally striking were the achievements of the shipyards. By mass-production methods, the assembling of pre-fabricated sections on a central way, and by electric welding and other new devices, ships were built in far shorter time than ever before. The first standardized type for mass production was called the Liberty ship; the second, larger and faster, the Victory ship Within two years after the launching of the first Liberty ship, the *Patrick Henry*, on Sept. 27, 1941, some 2,100 merchant ships totaling about 21,000,000 deadweight tons were completed. They made

possible the rapid transportation of American troops and supplies to all fronts. The tremendous shipyard production also gave the United States a merchant marine which far surpassed all the other merchant navies combined.

The March to Victory

It was agreed at the outset of the war that while the United States would fight hard in both the Pacific and the European-African theater, the greater part of its strength would first be bent to Germany's defeat. For a full year only a defensive war was waged in the Pacific. But this was signally successful, for in May 1942 a Japanese fleet was checked in the Battle of the Coral Sea; in June, a larger Japanese force was heavily defeated in the important Battle of Midway, losing four large aircraft carriers and a heavy cruiser; and in November, the enemy sustained another sharp reverse in a battle off Guadalcanal. These actions proved the definite superiority of the American navy and air forces. Meanwhile most of the vessels bombed at Pearl Harbor were being repaired, and powerful new units were rapidly being added to the fleet.

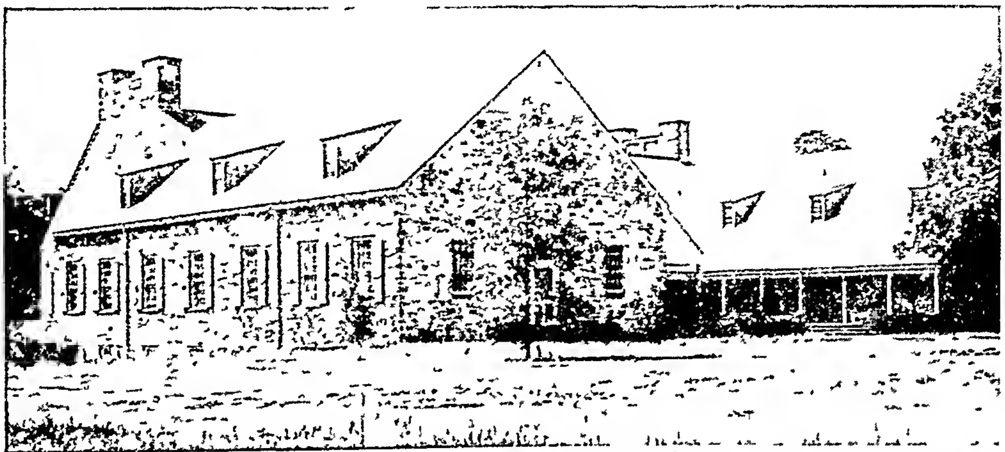
The first heavy American blow at Germany was struck when on Nov. 8, 1942, a strong Anglo-American force struck in French North Africa. They took the Nazi troops under Field Marshal Kesselring by surprise. The Americans and British, commanded by Lieut. Gen. Dwight D. Eisenhower, quickly conquered Algeria and invaded Tunis. Here they made a junction with the British army under Gen. Harold Alexander which had driven Rommel's troops eastward out of Egypt and Tripoli. By May 12, 1943, when the last German detachments surrendered, all North Africa was in Allied hands. It then remained to attack the Fortress of Europe.

This attack began on July 10, 1943, when an amphibious assault was launched against Sicily. American and British armies overran that island in a 39-day campaign, killing, wounding, or capturing nearly 170,000 Axis troops. The invasion of the Italian mainland followed on September 9, and Naples was swiftly captured. A hard slugging battle had to be fought for Rome, but it was finally seized with little damage in the spring of 1944. By that time the main effort had shifted to a new sector—to France, where the main German forces lay.

With the whole world tensely watching, Generals Eisenhower and Montgomery on June 6, 1944, threw a heavy force on the Normandy beaches, using two great artificial harbors which had been constructed in Britain. Bitter fighting at once developed, but the beachheads were soon made secure. "The crust of the German coastal defense system," writes General Marshall, "had been broken." The valuable port of Cherbourg fell on June 27. Then sufficient forces and materials were assembled to enable the Anglo-American armies to break out from the beachheads and strike toward Germany. Even at the beginning some 30,000 troops and 30,000 tons of supplies were landed every day. On July 25 Gen. Omar D. Bradley launched a grand offensive, and the Germans were rapidly pushed back. By August 25 Paris was in Allied hands.

The advance into Germany then continued with no serious setback save in the "Battle of the Bulge," a Nazi counter-offensive of December 1944, which temporarily threw the American troops back, but failed of its objectives. In February 1945, Roosevelt held a conference with Churchill and Marshal Stalin at Yalta, in the Crimea, to plan the final strokes of the European war and discuss questions of peace. Cologne was captured by American forces early in March, and British, American, and French forces rapidly cleared the enemy from most of the area west of the Rhine. Meanwhile, the Russians were advancing from the east. The Wehrmacht was pounded to pieces by Allied blows, and on May 7 all the remaining Nazi forces were surrendered to the Allies at Reims.

THE FRANKLIN D. ROOSEVELT LIBRARY



In 1939 President Roosevelt gave the government a tract of more than 16 acres from his Hyde Park estate and this $350,000 library. The building was financed by contributions solicited by the Democratic party and houses his public papers and correspondence. It is maintained by government funds as a memorial to the President.

Victory over Japan was not long delayed. During 1943 American, Australian, and New Zealand forces had taken the offensive in the Pacific. Heavy fighting in New Guinea resulted in clearing the enemy from important parts of that island. Late in the year the navy seized important bases on the road to Tokyo by capturing Tarawa and two other islands in the Gilberts. The United States, enjoying a clear superiority both in ships and in airplanes, was thereafter able to move much as it chose. In July 1944, Saipan in the Marianas, only 1,465 miles from Tokyo, was

taken, and that same month Guam was recaptured. Both islands made valuable air bases. On October 20, the country was electrified by the news that American soldiers under Gen. Douglas MacArthur, after an amphibious campaign that began in Australia, had at last fought their way back to the Philippines and landed on the island of Leyte. By the following February the American advance made possible the capture of Manila; and meanwhile Admiral Halsey, engaging the main Japanese fleet under Admiral Kurita, destroyed most of it and practically eliminated Japanese sea power.

Charter of the United Nations

President Roosevelt directed the American effort in close consultation with Prime Minister Churchill and other British leaders, and, as the war progressed, with Marshal Stalin. Repeated meetings were held in Washington, while a notable Anglo-American Conference took place at Quebec in August 1943. This was followed by a spectacular series of international gatherings later that same year. First Roosevelt, Churchill, and the Chinese generalissimo, Chiang Kai-shek, discussed common problems in Cairo. Then Churchill and Roosevelt proceeded to Tehran for several days of confidential talks with Marshal Stalin. They announced at the close that they expected to work in harmony, and hoped to see a "world family of democratic nations."

Nothing was closer to Roosevelt's heart than the formation of a new world organization, more effective than the old League. In this endeavor he had the earnest assistance of Secretary Hull, and the support of Congress, which by the Connolly and Fulbright resolutions in the fall of 1943 went on record as favoring a postwar coöperative organization among sovereign nations. On May 30, 1944, the American government invited Britain, Russia, and China to send delegates to a Washington conference on specific proposals for world peace. Discussions began August 21 at Dumbarton Oaks, a colonial mansion in Washington. After less than two months' work, a set of plans was drawn up and submitted for full study and discussion by the people of all nations. Roosevelt declared that a "ninety per cent agreement had been reached."

Meanwhile another presidential campaign was being hotly conducted. The Democratic party once more nominated Roosevelt; the Republicans chose Gov. Thomas E. Dewey of New York. Both party platforms vigorously endorsed American participation in a world organization, and Dewey no less than Roosevelt endorsed the idea. Substantially the entire country, in fact, seemed united behind an effort to organize peace and justice in a free world. In a White House broadcast on Oct. 5, 1944, and in other addresses, Roosevelt insisted that the Council of the United Nations must be given power to keep the peace by force, and that the American representative must be endowed in advance with authority to act quickly. No policeman could be useful, he said, if when he saw a burglar at work he had "to call a town meeting to issue a warrant before the felon could be arrested."

Roosevelt was reëlected for his fourth term with a popular vote of 25,602,505 against 22,006,278, and with 432 electors against Dewey's 99. He at once made it clear that he expected to see the United Nations turned into a permanent peacetime association with the fullest power to restrain all aggressors. In his message to Congress at the beginning of 1945, he said that the year just dawning "can be the greatest year of achievement in human history." It could witness final victory over the forces of Hitler and Mussolini; it could seal the doom of Japan. "Most important of all, 1945 can and must see the substantial beginning of the organization of world peace. This organization must be the fulfillment of the promise for which men have fought and died in this war."

The next step in the great world drama was the holding of a full international conference to draw up a charter for the world organization. Plans for this were laid at the Yalta meeting of Roosevelt, Churchill, and Stalin. The three leaders called a United Nations meeting at San Francisco on April 25, 1945, to turn the Dumbarton Oaks proposals into a finished instrument. President Roosevelt prepared to open the conference. Appointing a strong delegation under Secretary of State Stettinius, who had succeeded Mr. Hull when the latter fell gravely ill, he expected to keep in close touch with the proceedings.

President Roosevelt's Death

While delegates were gathering in San Francisco, and while American forces were daily thrusting deeper into Germany, Roosevelt went to his cottage at Warm Springs, Ga., for a brief rest. The morning of April 12 found him busy in the living room of the "Little White House." He was signing numerous documents and studying state papers. A portrait painter was making sketches of him. Suddenly he slumped sidewise in his chair, muttered, "I have a terrible headache," and became unconscious. He had suffered a massive cerebral hemorrhage, and death came swiftly. Late in the afternoon the news was being flashed to a shocked world. Just after seven o'clock that evening Harry S. Truman was sworn in as president.

The wave of emotion which swept over the country could be compared only with that which followed Lincoln's death. Though Roosevelt's domestic measures had sometimes aroused the bitterest antagonism in many people, everyone agreed that the nation had lost one of its greatest leaders. Millions of people had come to feel a warm personal affection for the man who had met the great depression so bravely; who had carried through a broader and deeper set of reforms than any predecessor; who had directed America's greatest war effort with signal efficiency and skill; and who had done more than anybody else to lay the foundations for the promising new world organization. His death, said Winston Churchill, was a loss "to the cause of freedom in every land." All the United Nations grieved as on a bright April morning he was buried in the garden of his Hyde Park home. On June 25, 1947, the "Little White House" at Warm Springs was given to the American people as a shrine.

The INSPIRING CAREER *of* AMERICA'S *Most* STRENUOUS PRESIDENT

ROOSEVELT (*rō′ zĕ-vĕlt*), THEODORE (1858–1919). Boy and man, cowboy and statesman, scientist and historian, soldier and sportsman—the American people have never seen quite the like of Theodore Roosevelt, 26th president of the United States. Had he not wished to devote most of his life to politics, he might have chosen from half a dozen distinct careers, and have gained eminence in any of them. He was as much at home in royal palaces as in the simplest cabin on the Dakota frontier. He was as resourceful in the African or South American jungle as in the White House. Not desiring wealth, he was not frightened by it. He loved power, yet he could use it with moderation. Once, when it was suggested that he would have more power if he were king, he replied indignantly: "Never; I know those kings. They resemble nothing so much as a vice-president for life, plus the leadership of the 400."

THEODORE ROOSEVELT

Rancher, hunter, explorer, author, soldier, statesman, 26th president of the United States, he accomplished in each of his chosen fields of activity as much as many distinguished men accomplish in only one.

Like Jackson, he founded a tradition that long outlived his life. He brought into the government of the United States at the turn of the century, and at the greater turn from local to world affairs, simplicity, honesty, directness, and the overwhelming desire that his children should find the United States as good a place to live in as he had found it. His omnivorous curiosity and aggressive spirit made imprints upon the business of the United States at home and the prestige of the United States abroad. He altered the character of the presidency itself, from a waiting job at the far end of Pennsylvania Avenue, to a cooperating and sometimes controlling job in contact with Congress at the other end of the avenue. But most of all, by the simplicity of his life and the homely virtues of his happy household, he set an example and gave new hope to the American citizen as he, too, faced the problems of a change in civilization. He was the apostle of the useful and strenuous life.

"I began my education early," he wrote "immediately after leaving college," but he never finished it, for his mind at 60 was as open to impressions as it had been at 20. And he may have misjudged the importance of Harvard College in the process, for he left it, in the class of 1880, with a character well formed and with intellectual interests that were never satiated.

When Theodore Roosevelt was a child, Abraham Lincoln, rail-splitter, ran for the presidency, and his supporters made much of his origin in the log cabin of the frontier. There was no pioneer's cabin in Roosevelt's background, no study by the flickering flame of the wood fire. He was born (Oct. 27, 1858) in a brownstone mansion in lower New York, into a family that had known wealth and culture for generations, with ancestors going back to the early Dutch in New Amsterdam. He was educated with all the resources of wealth at his disposal. He had private tutors and traveled widely. Instead of expecting to work for a living, he knew he would have enough money to do what he pleased. There was family tradition of work and service, with assured means behind it.

It may have been well for the young Roosevelt that this was so, for as a lad he was sickly, near-sighted, and asthmatic, and he might not have been able to cope with a tough world. But it was his own firm determination to build up a serviceable body that did as much to make him as all the family resources. He learned to ride and to shoot. He rather scandalized his elders by learning to box and by liking to box in public while in college. Indeed, throughout his life nothing was better indication of his technique than his adherence to the boxer's maxim that the best method of defense is to hit the adversary first.

His First Political Service

When he left college he went through the motions of studying law for a few months, but he really spent most of the first year in writing a 'Naval History of the War of 1812'. He appeared in the legislature of New York at the age of 23 and through three terms made himself respected, admired, and sometimes feared. In spite of his youth he was easily the leader of the Republicans in the legislature, and in 1884 was chairman of the New York state delegation to the Republican national convention, where he fought vigorously to secure the nomination of George F. Edmunds over James G. Blaine.

His defeat in this fight came only a few months after the death of his mother and of the wife he had married on his 22nd birthday. The combination

of family sorrows and political defeat seemed to turn his mind away from politics. For the next three years he lived the life of a cattle rancher, on the Little Missouri River in western North Dakota. His rough neighbors liked him in spite of his inexperience and his eastern accent, and he himself appreciated the true worth under their crusty and unprepossessing exteriors.

While he was on his ranch, in the summer of 1886, the Republicans called him to be their candidate for mayor of New York City. He ran a poor third to Abram S. Hewitt, the Democrat, who was elected, and Henry George, the expounder of the "single tax," but he is reported to have said, characteristically, that he "had a bully time." A few weeks later he married Edith Carow, a childhood friend, and settled down to a quiet literary life at Oyster Bay, Long Island. But the call to politics was in his blood; he saw duty and opportunity in public life. When President Harrison offered him the place of civil service commissioner he moved to Washington and for six years had the principal hand in building up the public services so that political influence might be lessened and the work of the nation advanced. He took the post of police commissioner in New York City in 1895, and tried to lift the metropolitan police out of the muck of politics.

President McKinley in 1897 made him assistant secretary of the navy; in this post his chief sometimes thought him like a "bull in a china shop," but his ideal was to make the navy a better servant of the United States. When the war with Spain approached, Roosevelt, who believed fully in its justice, on his own authority quietly ordered preparations for war. He proved his sincerity by taking a commission in the army, and by leading his Rough Riders, the First United States Volunteer Cavalry Regiment, recruited from plainsmen and college athletes, in the inspiring charge on Kettle Hill (wrongly called the charge on San Juan Hill). He came home from war to be nominated and elected governor of New York in 1898.

President at McKinley's Death

Roosevelt gained in popularity as one who was unafraid of tradition and unafraid of change. His gift for publicity and his startlingly aggressive strokes frightened the professional politicians whose timidity made them shrink from new issues. Those who were closest to him, notably Senator Thomas C. Platt, the Republican boss of New York, were glad that Governor Roosevelt came to be discussed as vice-presidential candidate when McKinley ran for a second term in 1900. And Roosevelt, despising the office as one that had no future, and protesting that he was not a candidate, nevertheless accepted the nomination and was elected. He presided over the Senate for a week during a special session; but before the time for the regular session of the Senate, McKinley had been assassinated, and Theodore Roosevelt, not yet 43 years old, was president of the United States.

In 1904, with Charles W. Fairbanks as running mate, he was elected president in his own right by a triumphant majority. He might perhaps have broken the two-term tradition, which had prevailed without exception since Washington declined to consider a third term, and have secured another reelection in 1908. But he declared that two terms were enough, and retired voluntarily in 1909 to as private a life as "an elderly literary man of pronounced domestic tastes" could live.

THEODORE ROOSEVELT'S ADMINISTRATIONS
1901–1909

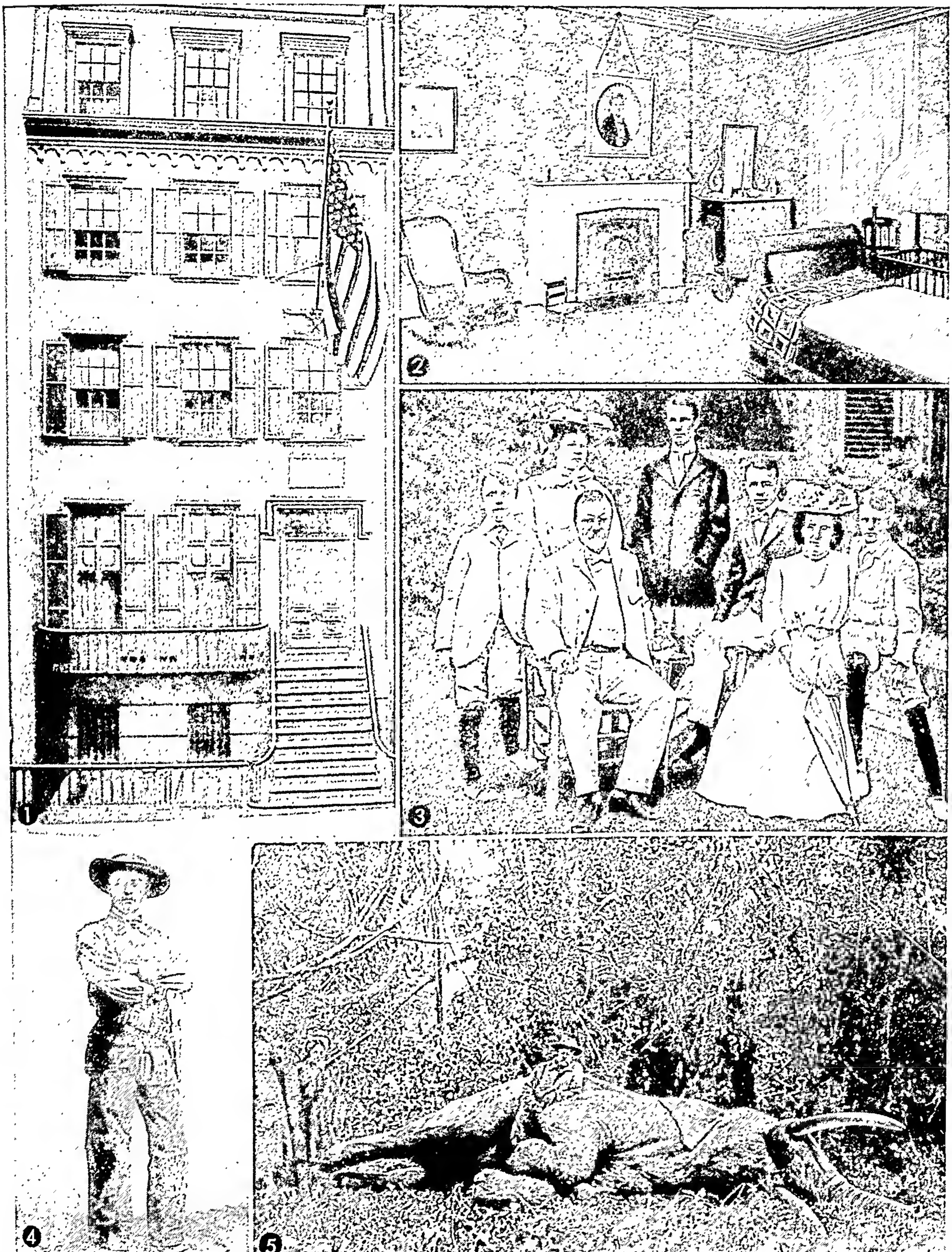
Coal Strike (1902).
Alaskan Boundary Dispute arbitrated (1903)
Department of Commerce and Labor created (1903).
Railroad Rebates abolished (1903).
Elected to full term (1904).
Treaty with Panama for building Canal (1904).
Louisiana Purchase Exposition (1904).
Beef Trust declared illegal (1905), and Standard Oil Company indicted.
Mediation by Roosevelt to end Russo-Japanese War (1905).
Intervention in Santo Domingo (1905).
San Francisco Earthquake, April (1906).
Hepburn Act regulating Railroad rates (1906).
Intervention in Cuba (1906–09).
Meat Inspection and Pure Food Acts (1906).
Oklahoma admitted as a State (1907).
Japan assents to "Open Door" Policy in China (1908).
Conservation Conference of state governors (1908).

Administrative Strength

Roosevelt inherited from McKinley a going organization, whose members he continued in their posts until, for reasons of their own, they chose to leave office. John Hay, his old friend, remained as secretary of state. After Hay's death in 1905 Elihu Root took charge of the office. Root had served from 1899 to 1904 as secretary of war, making a splendid record in the administration of the new foreign possessions as well as in reorganizing the army and eliminating the weaknesses which the Spanish-American War had disclosed. The creation of the army general staff and the foundation of the Army War College were largely his work. Root's work in the War Department was ably continued by William H. Taft, who was recalled from the Philippines to take this secretaryship.

To all his traits, Roosevelt added that of supreme administrator, who knew how to delegate duties and get results. Never hurried, he had time for everything. He brought play into the White House; built tennis courts in the rear of the grounds; took his friends on tramps over the hills of the Washington parks, and when army officers protested an order that they show fitness by riding 90 miles within 24 hours,

SCENES FROM "T. R.'S" LIFE STORY



1. Theodore Roosevelt was born in this brownstone mansion in New York City in 1858. 2. Here is the room in which he was born. By the fireplace is the little chair where he sat as his mother taught him his first lessons. 3. At their family home at Oyster Bay, N.Y., the President and the second Mrs. Roosevelt pose for a picture with their family. The children are Quentin, Ethel, Kermit, Theodore, Jr., and Archie. 4. As a young man on his North Dakota ranch, Roosevelt wears typical cowboy garb. 5. On an African hunting trip, Roosevelt shoots his first bull elephant.

he did it himself between two full working days. His cabinet worked with assurance and decision, under a chief who knew his mind. In the field of foreign relations much of the most decisive work was done.

Foreign Relations

The Alaska boundary dispute with Canada was adjusted during 1903. This dispute, pending since the discovery of gold in the Yukon, involved the meaning of the treaty concluded with Russia by England in 1825, defining the eastern boundary of the Alaskan "panhandle." Roosevelt let it be known to England that he was willing to submit to an arbitration before a special court of six, three members to be appointed by him and three by the British government. The American commissioners were Senator Henry Cabot Lodge, Elihu Root, and Senator George Turner; the British delegates were Baron Alverstone and two Canadians, Sir Allen B. Aylesworth and Sir Louis A. Jetté. Alverstone sided with the Americans on most of the points at issue. The two Canadians refused to sign the award, but it was accepted by both governments and the dispute was thus settled peaceably.

In the winter preceding the Alaska settlement, Roosevelt had occasion to consider how the Monroe Doctrine would be affected by an intervention in Venezuela by Germany, England, and Italy, to collect debts owed to their subjects. They proposed to seize and hold the custom houses, and to pay themselves out of the taxes as they collected them. Deciding that such seizure would be an impairment of the independence of Venezuela, Roosevelt brought pressure upon Germany and the other claimants to arbitrate the claims before the Court of Arbitration at The Hague. He later said that he secretly threatened Germany that he would use force if necessary to stop intervention and the seizure of Venezuelan custom houses.

In 1904, foreign creditors threatened to intervene in the affairs of the Dominican Republic. Apparently at Roosevelt's suggestion, the president of the Dominican Republic asked the United States to take charge of the collection of customs, and to divide the proceeds between the Dominican Republic and its creditors. The Dominican Republic after paying to its creditors 55 per cent of the revenues collected by an American agent, found that the 45 per cent allotted for expenses of government was larger than the whole revenue had been before. (*See* Dominican Republic.)

The Panama Canal

The Hay-Pauncefote Treaty, clearing the way for an American canal at Panama (*see* McKinley, William), was followed in 1903 by a treaty with Colombia granting the right to build it. But the Colombian Congress rejected this treaty, and in November 1903 the state of Panama, one of the states of the Colombian Republic, seceded, organized an independent republic, and itself by treaty gave to the United States the powers that Colombia had denied. Roosevelt knew about the plans for the Panama revolution, and certainly he gave it support, whether intentional or not, by ordering American naval vessels to keep any hostile forces off the isthmus and to prevent the Colombian troops at Colon from proceeding to Panama City. The President's explanation was that he wanted to avoid bloodshed, and that the United States was bound by treaty to keep the isthmian railroad open. The facts seem to be that he believed that Colombia was trying to blackmail the United States, and that civilization as well as American defense demanded that a canal be built at once. After experiments with a canal commission, he entrusted the work of construction to the United States Army. (*See* Panama Canal.) He sent Taft, secretary of war, to the canal to inspect the work, and later went there himself to get first-hand information.

The "New" Diplomacy of Directness

In dealing with foreign affairs in which the United States had no immediate interest, Roosevelt acted with a new directness which sometimes puzzled diplomats at the same time that it won their admiration. In 1905 he assisted Russia and Japan in bringing their destructive war to an end (*see* Russo-Japanese War); for this service he was awarded a Nobel prize for peace. In 1906, when France and Germany were ready to fight over their interests in Morocco, Roosevelt took the lead in arranging a conference of the powers at Algeciras. Under his instructions the American representative successfully supported the Germans in their effort to maintain an economic "open door" in Morocco, but the French won recognition of their "special position" politically.

Naval Policies of Roosevelt

American prestige was also helped by the improvements in the army and navy. Secretary Root's plans for army reform were firmly backed by the President, and these two men did much to prepare the army for the load that fell on it in 1917. Roosevelt also believed in a strong navy. He pushed Congress hard to get an appropriation for two new battleships a year, and he kept the fleet to a high standard of efficiency. This was demonstrated by the cruise around the world of 16 battleships, all new since the Spanish-American War. President Roosevelt decided on this cruise in 1907 at a moment when relations between Japan and the United States were very critical because of anti-Japanese agitation in California and in Congress, and he always regarded it as one of his most important contributions to world peace. In a letter to Secretary Root he wrote:

> It is high time, however, that it (the navy) should go on a cruise around the world. In the first place I think it will have a pacific effect to show that it can be done; and in the next place . . . I became convinced that it was absolutely necessary for us to try in time of peace to see just what we could do in the way of putting a big battle fleet in the Pacific, and not make the experiment in time of war.

By the close of his presidency, Roosevelt had made it clear (1) that the United States desired peace; at the Second Hague Conference in 1907, the United States delegation took a lead for peace that European powers would not follow; (2) that the United States was prepared to defend its rights, on land or sea,

although it was not disposed to provoke a fight; (3) that the Monroe Doctrine would be maintained by whatever action might be necessary; (4) that, on the other hand, the Latin-American countries would not be allowed to hide behind the Monroe Doctrine as a means of evading their just duties; and (5) that wherever possible the United States, in coöperation with the neighboring republics, would assist them in maintaining order and meeting their obligations. It was also shown (6) that in matters directly relating to the defense of the United States and of the Panama Canal, the United States would act decisively and effectively.

Domestic Problems

Within the United States, Roosevelt found his actions restricted by the need to keep Congress in agreement with him, and by the power of the courts to pass upon the legality of acts. He faced a growing hostility towards himself, on the part of politicians, as he grew more direct and more popular. He faced a more bitter hostility from the managers of "big business" as he took, time after time, positions that favored the people at large against the trusts, and the rights of labor against those of the employer. The boom of a new period of prosperity, visible before the death of President McKinley, became a dominant note in 1901–02. It had distinct results in manufacture, transportation, and labor relations.

The age of steel had begun after the Civil War, when new processes made steel cheap and invaluable for railroads, ships, bridges, and skyscrapers. In 1901 the United States Steel Corporation was formed to control a large share of the total business, and to manage within its own properties every stage in the process from the mine to the finished product. This was the first of the great "vertical trusts" including iron and coal mines, railroads, ship lines, foundries and smelters, rolling mills, and every type of factory for making everything from fence wire and cast iron pipe to locomotives. A new empire of big business threatened to sweep the land. Once more, as before 1890, the people's fear of being dominated by trusts arose. This time the fear was magnified and intensified. It was Roosevelt's view that the trust, just like the common man, must obey the law. But the question was whether a suitable law existed; for the Sherman Act of 1890 seemed to have no teeth.

The Railroad Mergers of 1901

Following close upon the industrial mergers, of which the steel corporation was the largest, came a series of railroad mergers. The Union Pacific System, first across the continent in 1869, came to life again after the panic of 1893, and began buying and renting other lines. In 1901 it bought control of the whole of the Southern Pacific System, thus consolidating a railroad empire that threatened with monopoly the whole southwestern quarter of the United States. Close upon this, the Northern Pacific, the Great Northern, and the Burlington systems were brought together under the Northern Securities Company, constituting another near-monopoly, this time over the northern half of the Far West.

In 1902, through Atty.-Gen. Philander C. Knox, Roosevelt brought suit under the Sherman Act, for the dissolution of the Northern Securities Company as a conspiracy in restraint of trade. The United States won the suit. By this time Roosevelt was being called the "trust buster," a useful term in getting votes. Suits were begun against the United States Steel Corporation, the Standard Oil Company, and other large combinations, but the President tried to make it clear to the people that mere size was not the trouble; that it would be better to stop bad practises than to try to break up the corporations.

Naturally big business thought the President too radical, for his proposed reforms threatened to reduce profits. The President, on his side, was appalled by the attitude of some of these men. In a letter to Senator Lodge he quoted Harriman, who controlled the Union Pacific System: "Harriman answered . . . that whenever it was necessary he could buy a sufficient number of senators and congressmen or state legislators to protect his interests, and when necessary he could buy the judiciary. These were his own words. He . . . showed a perfectly cynical spirit of defiance throughout, his tone being that he greatly preferred to have in office demagogues rather than honest men who treated him fairly." Roosevelt's own attitude he expressed in a letter to a New York banker: "I wish to do everything in my power to aid every honest business man, and the dishonest business man I wish to punish simply as I would punish the dishonest man of any type. My prime object is to prevent injustice and work equity for the future."

Passage of the Pure Food Law

From every side, suggestions began to come to Congress for more laws to help the people against big business. A Department of Commerce and Labor was added to the cabinet in 1903. The Pure Food Law was passed in 1906, requiring the packers of food to label correctly what they sold, and forbidding the use of injurious drugs and adulterants. In the same year the Hepburn Law was passed, extending the powers which the Interstate Commerce Commission had exercised since 1887, and specifically giving it the right to fix rates and making it a quasi-judicial tribunal.

The continued attacks on large corporations undoubtedly helped to bring on the panic of 1907. In 1906 Charles E. Hughes led an investigation of the New York insurance companies (*see* Hughes, Charles Evans), and disclosed many abuses which created public distrust of the existing managements. The uneasiness of the public was indicated in the stock market early in 1907, but did not come to a head until October, when the Knickerbocker Trust Company, in New York, failed. Though the country as a whole was prosperous, the reserves of almost all the nation's banks were concentrated in New York. There the money crisis became acute, and "runs" started on many of the trust companies and other financial institutions.

The banks refused to pay out cash, but issued "clearing house certificates," secured by gold and securities in the hands of members of the clearing house. Chicago and other large cities followed New York's example, until in all about $250,000,000 was added in this way to the currency in circulation. Such certificates had been issued several times during the Civil War, in the panics of 1873 and 1893, and at several other critical periods.

Roosevelt established a friendlier relationship with labor than any previous president had done. In 1902 there was a great strike among the coal miners in the anthracite fields of Pennsylvania. The miners kept good order, so that there was no excuse for troops. The mine owners refused stubbornly to deal with the unions. As winter approached, Roosevelt made ready to take over and to operate the mines in the interest of the public, but he also brought such pressure upon the owners that, unwillingly, they agreed to arbitrate. The President appointed a special commission of seven, and the verdict of these men, giving the strikers a part of the wage increase they wanted, was accepted by both sides. Labor, which had sometimes believed that the government was always against the workers, continued to give Roosevelt strong support.

The Far West always held a particular interest for President Roosevelt, for there he had passed years upon his Dakota ranch and there he had often traveled hunting big game. He assisted in 1902 in the passage of a Reclamation Act for building great irrigation dams and canals in the arid states (*see* Irrigation and Reclamation). In 1908, he gathered at the White House a conference upon the conservation of natural resources, assembling there governors, university presidents, men of business, and scientists to consider what policy ought to be adopted to preserve the national estate for posterity. One result of this conference was the formation of the National Conservation Commission (*see* Conservation).

Roosevelt had done his best work in reviving the conscience of the people upon matters of social justice, and in holding their attention to the great policies to be undertaken by the United States so that the ordinary man might remain economically free in spite of great combinations of wealth. He secured the Republican nomination for his friend William H. Taft, and left to him the arduous task of carrying out the measures that had come to be known as the "Roosevelt policies" (*see* Taft, William Howard).

The Ex-President

The United States makes no provision for using its ex-presidents. Roosevelt left the White House only 50 years of age, with wide interests, ample private means, and the prospect of many years of active life. He knew that he had reached the climax of his career, and that nothing again could be as exciting as having been president. He took up his residence at his country estate on Long Island, at Oyster Bay, and became the most important private citizen in the United States.

He resumed his travels, and the hunting trips that were also scientific expeditions. These hunting trips of Roosevelt were those of a naturalist, not interested in killing game but thrilled with the thought of discovering new varieties and gathering specimens for museum use. Early in life, he had helped to found the Boone and Crockett Club, whose mission was the preservation of American big game. When he left the White House in 1909, he departed at once to Africa, where he led an expedition into the interior, for the American Museum of Natural History. He explored the back country of Brazil in 1914, nearly losing his life through disease and accident. But he located what had appeared upon the maps as the River of Doubt, and the Brazilian government promptly renamed it the Roosevelt River in his honor.

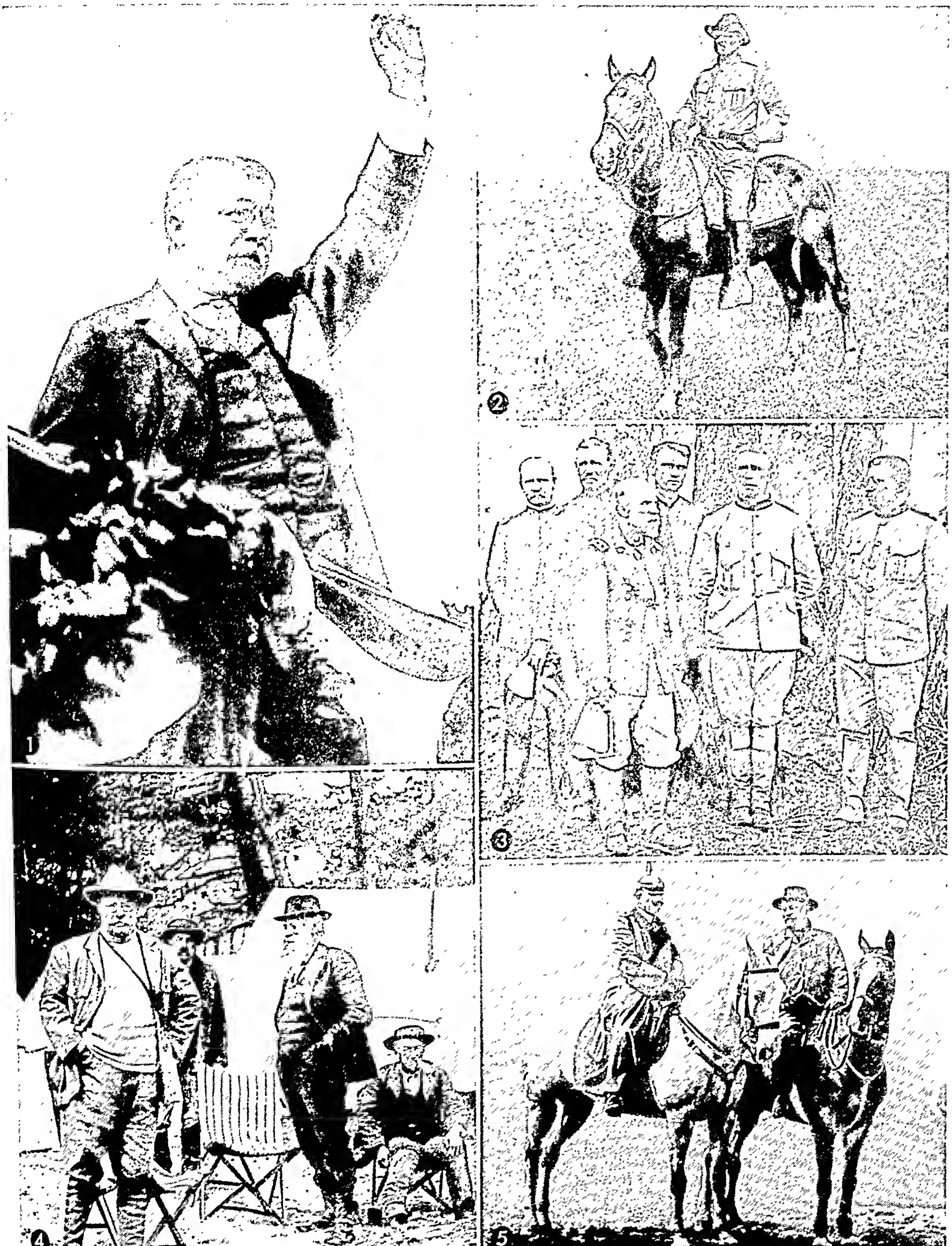
His Return to Politics

On his return from Africa in the summer of 1910, he was drawn back into politics. He was inspired by a belief that Taft had failed to carry through the Roosevelt policies, and that he was needed to preserve the life of the progressive movement which he had helped to start. He spoke and wrote on "new nationalism," meaning by this that the United States must control all forms of business sufficiently to protect the interests of the American people; and that if the Constitution did not grant enough powers for doing this, the Constitution must be amended. His friends, who could not get used to his absence from politics, urged him to be a candidate for president in 1912. Politicians too, who cared little for him personally, urged his return, because they believed that he alone could prevent the election of a Democratic president. He was beaten for the Republican nomination by Taft, under circumstances which led to charges of fraud and "steam-roller" methods.

Thereupon the Roosevelt followers organized a new party, the "National Progressive," held another convention, and nominated Roosevelt for president and Senator Hiram W. Johnson for vice-president. The party was nicknamed "Bull Moose," because Roosevelt, once when asked how he felt, replied that he was fit as a bull moose. The platform demanded direct primaries, direct election of senators, the initiative and referendum, suffrage for women, and other reforms of a social-economic nature. An enthusiasm that was almost religious animated the new party. The campaign was bitter, and Roosevelt's attacks on the "stand pat" Republicans were more venomous than on the Democrats who were his normal opponents. Though not expecting to win, Roosevelt led a gallant fight, and made a two months' speaking tour of the country. In Milwaukee, at the height of the campaign, he was slightly wounded by a crazy man who shot at him. Roosevelt polled 4,126,020 votes, to 6,286,214 for Wilson, and had 88 electoral votes to 435 for Wilson. Taft was third with 3,483,942 popular votes and 8 electoral votes.

When the first World War came, he followed it with keen understanding. From the first he felt that

THEODORE ROOSEVELT, MAN OF ACTION



President Roosevelt was statesman, soldier, and world traveler. 1. He campaigns for president, speaking with forceful gestures. 2. In the Spanish-American War, he recruited the dashing Rough Riders and commanded them in battle in Cuba. 3. Here Colonel Roosevelt meets with fellow officers. In front is Gen. "Fighting Joe" Wheeler. The other officer in khaki is Col. Leonard Wood. 4. At Yosemite National Park he visits the famous naturalist John Burroughs. 5. In 1910 Roosevelt observes German army maneuvers with Kaiser Wilhelm.

Germany was in the wrong, but he wished to avoid any action which might embarrass President Wilson in formulating a policy of neutrality. Very soon, however, he decided that Wilson "had no policy whatever," and said so in a letter to Rudyard Kipling. Thereafter, until the United States was drawn into the war, he felt that nothing the Democratic administration could do was right. Roosevelt led rallies for "preparedness," urging Congress to complete the arming of the United States before it was too late. He denounced every form of pacifism. He refused the Progressive nomination for president in 1916 and supported Hughes, the Republican nominee, against Wilson, who was re-elected.

He Offers to Serve in the War

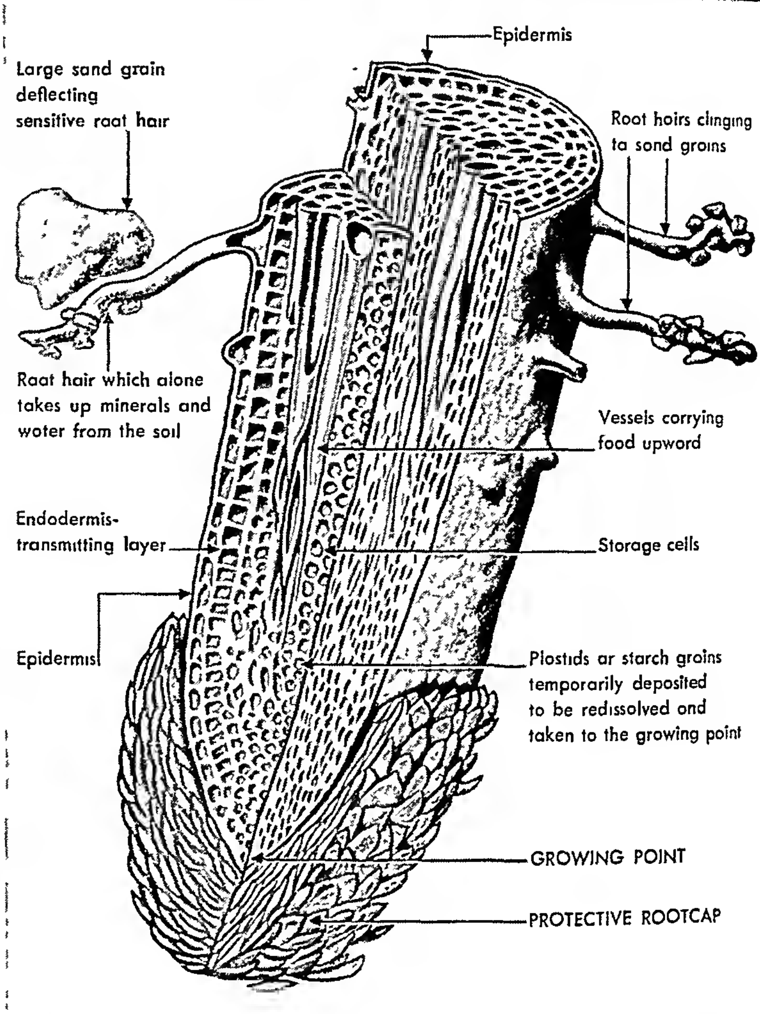
When at last the United States declared war against Germany, Roosevelt hurried to Washington to offer his services. For nearly a year he had been ready, with a skeleton organization of a division, and with acceptances from all the higher officers he would need. But there was no place for Roosevelt in the war. He was nearly 60 years of age. He was not a professionally trained soldier, and high military command was entrusted only to those who were. He was physically unfit, for he never fully recovered from the fevers which attacked him during his search for the River of Doubt. Furthermore, he had long since lost the sight of an eye through an accidental blow while boxing for exercise.

Although he could not go himself, his four sons and his son-in-law were all in active service. Quentin, the youngest son, a pilot in the aviation forces of the United States, lost his life in action.

As the war progressed, Roosevelt led in the demand for ever greater activity, but worn out by strenuous activity, his health failed, and on Jan. 6, 1919, he died quietly in his sleep. He is buried in the cemetery near Sagamore Hill, his home at Oyster Bay. In 1953 this home became a national shrine. Roosevelt's boyhood home, at 28 East 20th Street in New York City, has been made into a museum by the Roosevelt Memorial Association.

Roosevelt's chief writings are: 'Ranch Life and Hunting Trails' (1888), 'The Winning of the West' (1889–96), 'American Ideals and Other Essays' (1897), 'African Game Trails' (1910), 'Theodore Roosevelt, an Autobiography' (1913), 'Life Histories of African Game Animals' (1914), 'Through the Brazilian Wilderness' (1914).

THE "BRAIN WORK" OF THE ROOTS



This picture shows a root much enlarged, with its rootcap and roothairs. When a rootcap meets an obstacle, the root bends, not at the tip but higher. The rootcap has "telegraphed" in some way to parts higher up to push it in a different direction.

Root. Plants have roots to serve two important functions—to anchor and support the plant, and to absorb water and dissolved minerals from the soil.

We usually think of roots as growing downward into the ground. But many plants have roots that grow in the air. Among them are the orchids and the climbing roots of English ivy. In other plants roots grow partly above ground. The prop roots of corn do this. So do the roots that grow from the stems of banyan and mangrove trees.

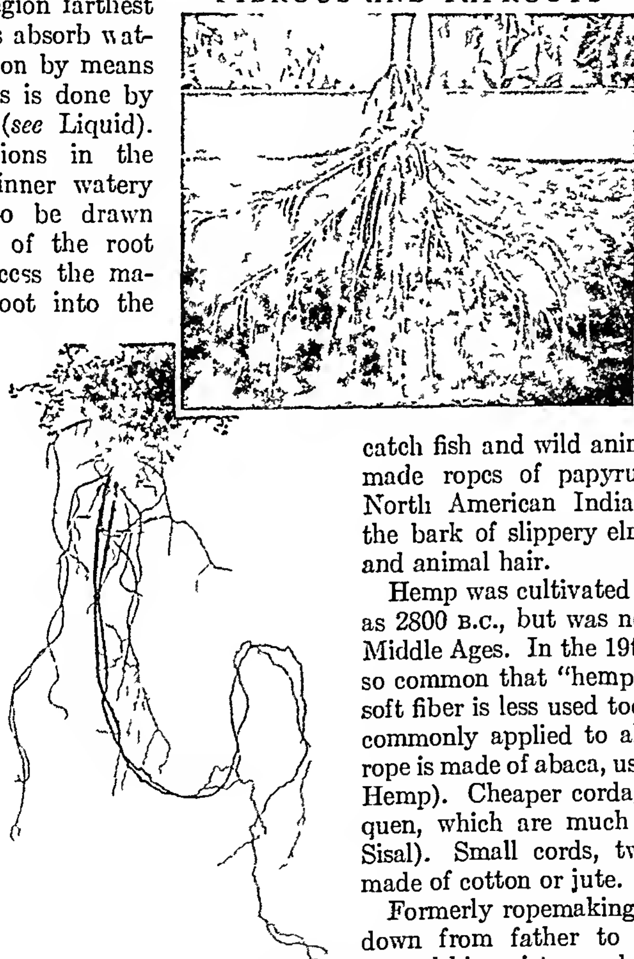
A plant has a *taproot* system when it has one stout, main root extending downward for some distance. Smaller secondary roots may branch from it. Oak and hickory trees, carrots, dandelions, alfalfa, burdock and ragweed have taproots The *fibrous root* system is very different. It consists of many long, slender roots of about equal size. Corn, wheat, and other cereals, grasses, and beans have such roots. Some plants, like radishes and turnips, store food in their roots and become very large. These are

called *fleshy* roots. Usually they are also taproots. When several roots become fleshy, as in the sweet potato and dahlia, they are known as *clustered* or *fascicled* roots.

Rootcap and Root Hairs

A root can best be studied by watching a sprouting seed. The first structure to break out of the seed coat is the root (*see* Seeds). The tip of the root is covered with a blunt, thimble-shaped rootcap. It protects the delicate growing tip, for the root is literally *forced* through the ground. Practically all roots have this cap, even those that grow in water or air and do not seem to need protection. Behind the cap are many fine root hairs. They are constantly being renewed nearest the rootcap and dying off in the older region farthest from the rootcap. Roots absorb water and minerals in solution by means of their root hairs. This is done by the process of *osmosis* (*see* Liquid). The thicker sap solutions in the root cells cause the thinner watery solutions in the soil to be drawn through the membrane of the root hair. By the same process the materials pass from the root into the stem and leaves of the plant.

FIBROUS AND TAPROOTS



The top picture shows a corn plant with its fibrous root system. All the roots are of equal size and length and usually wide-spreading. Bottom, is the taproot of an alfalfa plant. It consists of a long, main root, with smaller branching roots. Alfalfa roots may be 30 feet long.

Root hairs develop best in well-aired, moist soil. They do not develop at all in most plants that grow in water, as the duckweed and the spatterdock, or yellow pond lily. Root hairs cling to soil particles tightly and the hairs are usually left behind when a plant is pulled up. Hence roots are a most important factor in erosion control. They bind soil in place and prevent it from being washed away by rains or blown away by wind.

It is popularly believed that roots "nourish" the plant. This is a mistake. The water and dissolved minerals taken up by the roots are essential to the building of the plant cells. But the largest proportion of the plant's food by far is derived from carbon dioxide absorbed by the leaves (*see* Leaves).

In some plants the roots may serve as asexual reproductive organs. Under certain conditions, such as exposure to light, the roots may develop irregular "adventitious" buds from which leafy shoots grow. This is true of sweet potatoes, roses, apples, poplars, black locust, and Osage orange. The leafy shoots produce new plants.

Size and Strength of Roots

Roots in general grow downward in response to gravity and in the direction of water. In desert regions where there is little moisture, they are shallow but have a wide spread. The Spanish bayonet, for example, has roots that are only 18 inches deep, but it has a spread of 30 feet. Most Middle Western plants average three to four feet deep with a spread of one to four feet. But the taproot of alfalfa grows 10 to 30 feet deep.

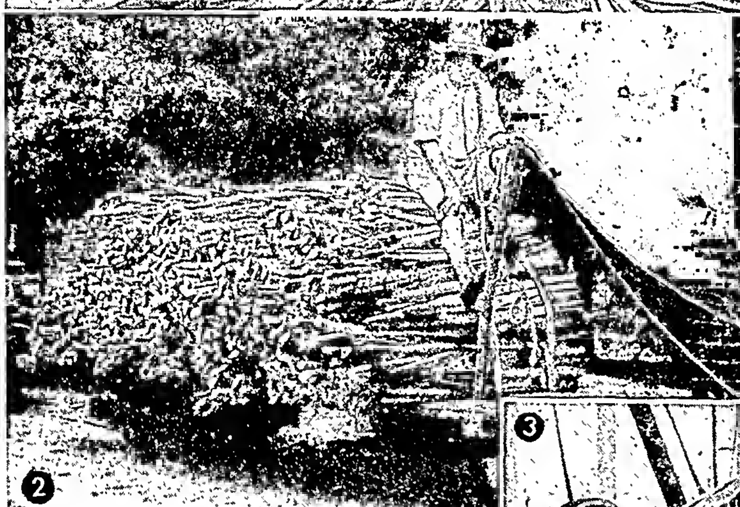
Roots exert remarkable force as they grow. In rocky places slender tree roots enter small crevices and split the rock as they enlarge (*see* Plant Life).

ROPE AND TWINE. Long before the beginning of history men learned to make strong ropes by twisting together reeds or roots, strips of hide or bark, to form long strands. In the late Stone Age the lake dwellers made cords of flax and fashioned them into nets to catch fish and wild animals. The ancient Egyptians made ropes of papyrus and palm fiber, and the North American Indians used yucca, agave, and the bark of slippery elm or willow, as well as hides and animal hair.

Hemp was cultivated for its fiber in China as early as 2800 B.C., but was not grown in Europe until the Middle Ages. In the 19th century its use had become so common that "hemp" meant "rope." This rather soft fiber is less used today, but the name "hemp" is commonly applied to all rope fibers. Our strongest rope is made of abaca, usually called Manila hemp (*see* Hemp). Cheaper cordage is made of sisal and henequen, which are much used for binding grain (*see* Sisal). Small cords, twine, and string are usually made of cotton or jute.

Formerly ropemaking was a skill that was handed down from father to son. The spinner wrapped around his waist a wad of combed fibers, attaching a few to a hook on a spinning wheel, which was turned by a boy. Then he walked backward from the wheel, paying out the fibers from each hand as he walked. The length of the "ropewalk" determined the length of the rope that could be spun. To prevent friction of the dry fibers, the strands or finished ropes were dipped into tar. Rope was made in Boston as early as 1642, and ropewalks multiplied rapidly in seaport towns. A large demand was created by the fishing industry and sailing vessels. Modern methods of manufacture began with the invention of a rope-twisting machine in England in 1820.

THE RAW MATERIAL OF ROPE MAKING



1. Mexican laborers trim young henequen plants before transplanting them in nursery fields. These plants provide the sisal fiber from which much of the world's rope and twine are made. 2. A native of Yucatan hauls henequen leaves, each weighing about two pounds, to the mill, where the fiber is separated from the pulp. 3. Sisal hemp coming from the separating machine. 4. Abacá (Manila hemp) fiber drying in the sun before being baled for shipment to the twine mills.

The raw material arrives at the ropemaking plant in great bales. It is loosened, spread in layers, sprinkled with oil, and then "heckled" or mechanically combed to clean and straighten the fibers. The fibers are twined and twisted end to end into one continuous *sliver* on machines called "breakers." Later the slivers go to the spinning machines. These twist the fiber right-handed into yarns, which are mechanically wound onto huge bobbins.

From the bobbins the yarns are fed to the strand-forming machine through holes in an iron face plate, so placed that the yarns all converge into a tube. There they are compressed into a bundle and twisted into strands by the revolution of a long carriage or flier. In the "laying" machine the strands again pass through openings and converge in a central tube, through which they pass to a second set of revolving fliers; and these twist the strands together into rope. (In the most complete ropemaking instrument the strand-forming machine and the laying machine are combined.) Thus ropemaking is a series of twisting processes; and each twist is in a direction opposite to that of the preceding twist, so as to make the finished product tight and hard. Ropes are twisted together to form a larger rope, hawser, or cable.

The cordage is still frequently covered with pine tar or other tar (by means of copper troughs and pressing rollers) to protect it from the effects of moisture. So that it will penetrate and stick to the rope, the tar is heated to 200° F.

Large hemp ropes have been superseded for most purposes by metal cables, made of strands of copper, iron, or steel wire twisted together in much the same way as ropes are made.

AND THIS IS HOW IT IS MADE INTO ROPE

1. Bales of fiber are stored away in the warehouse until needed in the mill. 2. After the bales are opened and the dirt and snarls are combed out of the fiber, it is oiled and then put into this breaker-spreader machine, which forms the fiber into long ribbons called "roping" or "sliver." 3. The sliver is pulled into a spinning jenny by a revolving endless chain. This machine draws the roping into a tube which compresses it to the desired thickness, after which the yarn is twisted on a large bobbin. 4. From the spinning jenny a number of yarns are drawn into a forming machine which squeezes them into a single strand. 5. The laying machine twists three, and sometimes more, strands together to make the finished rope.

MODERN ROSES HAVE INFINITE VARIETY

CHARLOTTE ARMSTRONG

FASHION

Above are two patented roses. The Charlotte Armstrong, a hybrid tea, is a long-stemmed rose with large light-red flowers. It is handsome and hardy but lacks fragrance. Fashion, a hybrid polyantha, has small coral-peach blossoms and a wild-rose fragrance.

ROSE. The best-loved of all flowers is the rose. Its clear colors, its fragrance, and the beauty of its form have made the rose a favorite since ancient times. Rose growers can create apparently endless new varieties, and this has increased the popularity of the flower. Today there are roses to suit every taste and almost every climate. Wherever man can have a garden he can have roses.

All present-day roses are descendants of wild roses. We may doubt this if we compare a full-flowered cultivated bloom with a five-petaled swamp or prairie rose. But many wild-rose species tend to bear double blooms—flowers with more than five petals. A skillful gardener can select a wild rose plant that shows an occasional double blossom, give it and its descendants expert care for several years, and produce plants that consistently bear handsome double flowers.

Until the 19th century all rose culture was of this type. Many species were popular for cultivation, including cabbage, damask, and French roses. The cabbage (*Rosa centifolia*) is a large pink rose that grows wild in the Caucasus. It was cultivated in ancient Greece and Rome. Later the French called it the Provence rose. The fragrant rose-pink damask (*R. damascena*) may have grown in ancient Babylon. The Crusaders saw it in Syria. The French rose (*R. gallica*), a dwarf with pink to crimson flowers, was native in Europe. The pink moss rose, with mossy bud and stalk, appeared as a "sport" of the cabbage rose in 1596.

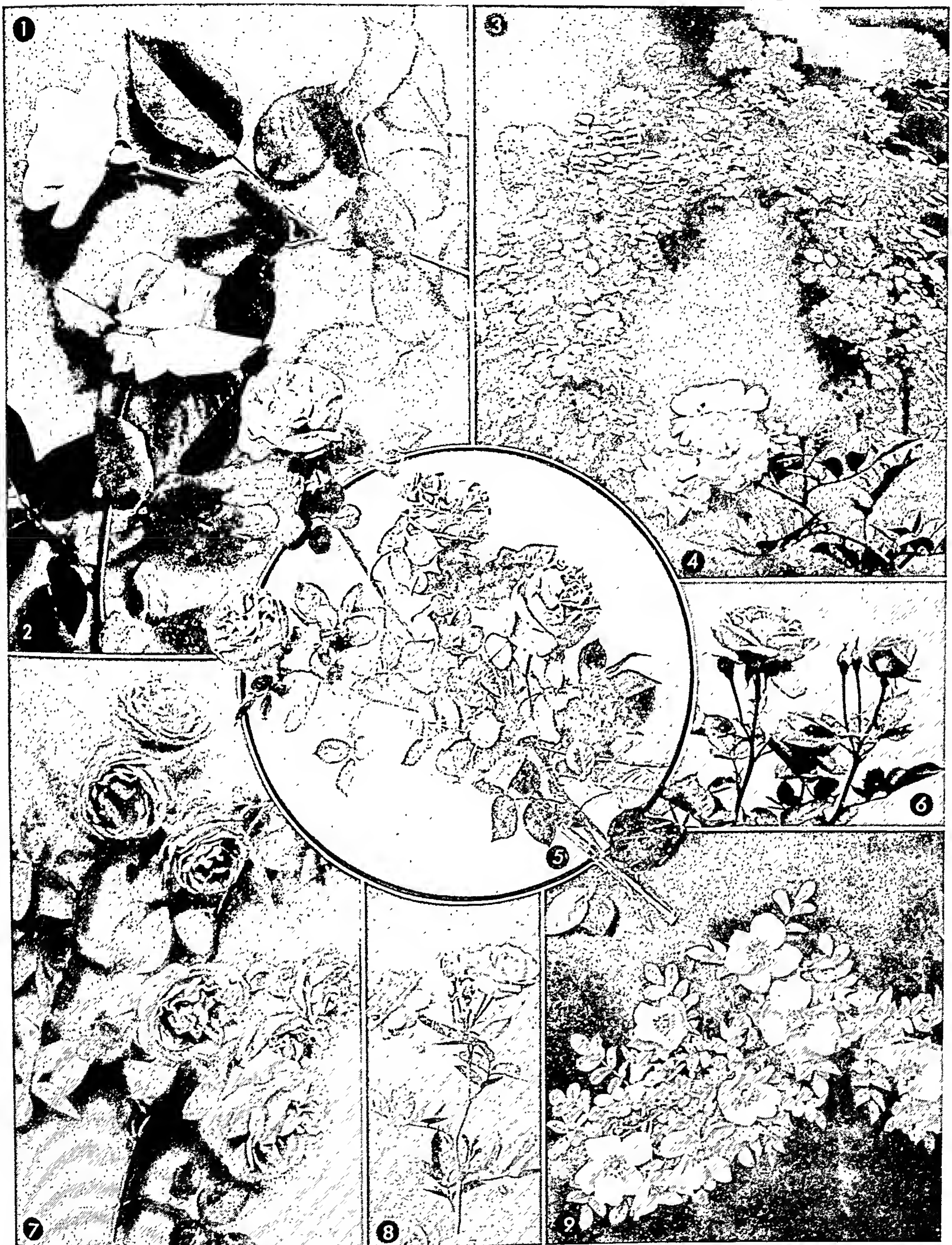
Early cultivated species had one blooming period, usually in June. Only the damask broke this rule, by occasionally blooming again in autumn. China roses (*R. chinensis*) appeared in Europe in 1789. These bloomed several times, often monthly. This habit earned them the name "everblooming." The French term *remontant* ("repeating") is more accurate. The tea rose (*R. odorata*), a remontant rose with a tealike fragrance, came from China in 1810.

The possibility of having roses in flower throughout the garden season stimulated interest in rose culture. Rose growers also learned how to crossbreed species and produce desirable *hybrids*. Rose breeding had become commercially successful in most countries by the early 1900's. In 1930 the United States Plant Patent Act gave protection to inventors of new varieties. Present-day rose breeders and rose growers in this country do a 20- to 30-million-dollar business each year. (*See* Plant Life, subhead "How Men Improve Plants.")

Modern Garden and Hothouse Roses

There are two major divisions among modern roses —bush roses and climbing roses About 90 per cent of roses listed in catalogues are bush roses and about 10 per cent climbers. Each division has a number of classes, and each class has hundreds of varieties produced by crossbreeding. The first class of bush roses to become important was the hybrid perpetual. Rose growers produced it by crossing the everblooming China rose with hardier cabbage, damask, and French roses. This class reigned in garden and greenhouse from about 1860 through the 1890's. The flowers are handsome, but they usually appear only in June.

FAMOUS ROSES OF YESTERDAY AND TODAY



1. Ophelia, a salmon-colored hybrid tea introduced in England in 1912. It is an ancestor of most florists' roses grown in America and of many famous garden roses, including Crimson Glory. 2 Columbia, a fragrant pink rose descended from Ophelia. This was once the leading hothouse rose. 3. A rambler rose. 4. A polyantha. 5. American Beauty, a fragrant, deep-pink hybrid perpetual. In 1886 this rose was brought from France to the United States. For many years it was a symbol of beauty, but it is little grown today. 6. Radiance, a sweet-scented hybrid tea. Radiance appeared in 1908 and is still a favorite. 7. Yellow Maréchal Niel, developed in France in 1864. 8. A China rose. 9. Prairie rose, the common wild rose of eastern North America.

THREE FINE PATENTED ROSES

CRIMSON GLORY — MIRANDY — PEACE

Crimson Glory is one of the most popular garden roses. It is vigorous, flowers freely, and is very fragrant. Mirandy has big garnet-red flowera with damask-rose fragrance. It thrives in hot dry weather. Peace bears lemon-yellow buds edged with pink, which open into ruffled, pale pinkish-yellow flowers. It is sturdy and moderately fragrant. These three varieties are hybrid teas.

Hybrid teas succeeded hybrid perpetuals in popularity. They are a cross between hybrid perpetuals and the tea rose and bloom more freely than the former. Today almost all florists' roses and three-fourths of those sold to gardeners are hybrid teas.

Other important classes of bush roses are: polyanthas, bred from a dwarf form of *R. multiflora,* a Japanese rose that bears many flowers in clusters; hybrid polyanthas (floribundas), which combine chiefly polyantha and hybrid tea varieties, and miniatures, tiny varieties bred from the China rose.

Climbing roses have been bred chiefly from the Japanese rose (*R. multiflora*), the memorial rose (*R. Wichuraiana*), and the wild prairie rose (*R. setigera*) crossed with bush roses. Classes include ramblers, large-flowered climbers, and pillar roses.

About 10,000 people in the United States belong to the American Rose Society. This organization publishes an *Annual* containing critical reports from all over the United States on new varieties. It keeps in close touch with similar societies in other countries.

Roses grow wild throughout the north temperate zone. They belong to the genus *Rosa* of the family *Rosaceae.* They are erect, climbing, or trailing shrubs, usually with prickly or hair stems. Flowers are borne single or in terminal clusters and are followed by a berrylike fruit, or *hip.* The best-known American species are the prairie rose (*R. setigera*), swamp rose (*R. palustris*), and Carolina rose (*R. carolina*). The Cherokee (*R. laevigata*) came originally from Japan.

Roses, Wars of the. A quarrel between the noble families of York and Lancaster over the right to occupy the English throne brought on a series of cruel civil wars in England in the years 1455–85. The emblem of the Yorkists was a white rose and that of the Lancastrians a red rose. The wars were therefore called the Wars of the Roses.

The table on the next page shows how the families of York and Lancaster were descended from King Edward III. Henry VI, head of the Lancastrians, represented the third line of descent from Edward III. Richard of York was descended through his mother from Edward's second son and through his father from the fourth son. Thus the Yorkists had a better claim to the throne than the Lancastrians. But they had been passed over in 1399 when Richard II was deposed, and would have won no backing later if it had not been for the failure of the English armies in the Hundred Years' War (*see* Hundred Years' War), the mental and physical weakness of King Henry VI, and the excessive taxation and misrule at home.

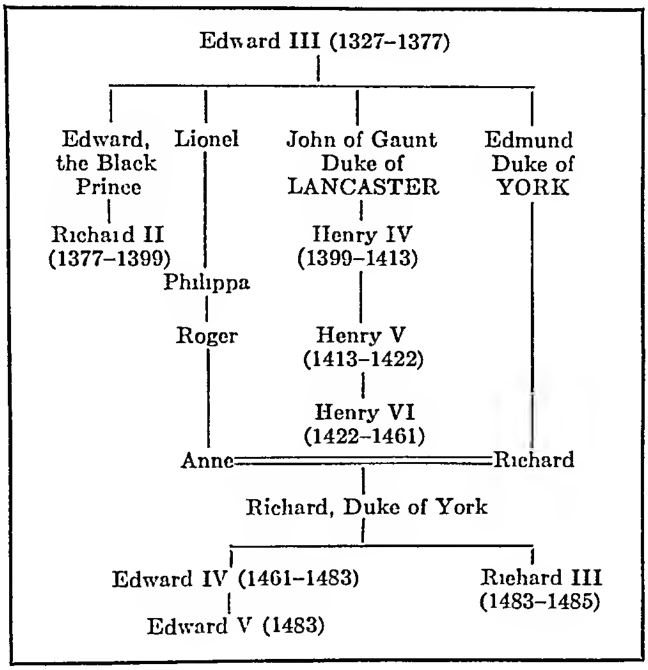
At first Richard of York planned merely to take the government from incapable persons and secure it for himself. Later his ambition was to seize the crown His ablest supporter was the Earl of Warwick. The earl played so important a part, first on one side and then on the other, that he was called "the Kingmaker." On the Lancastrian side the real head of the party was Queen Margaret, a young and beautiful French-woman, who fiercely resisted attempts to dethrone her husband, Henry VI, and disinherit her son, Edward.

The struggle began with the battle of St. Albans in 1455. Richard of York was victorious and secured control of the government. Four years later the contest was renewed. Richard was finally defeated and killed by the forces of Queen Margaret at Wakefield (1460). But his strong and able son obtained the throne with Warwick's help and became king as Edward IV, the first of the Yorkist line. Poor insane Henry VI was shut up in London Tower. Then Warwick quarreled with Edward IV and helped Queen Margaret drive him from England and restore Henry VI (1470). The next year Edward returned and Warwick was defeated and killed in battle. King Henry's young son was murdered at Tewkesbury (1471). The King himself was assassinated the day Edward IV re-entered London and seized the throne again.

This ended the first period of the struggle. Fourteen years later war broke out again, and Henry Tudor, the last Lancastrian representative, defeated and killed Richard III, last Yorkist king, at the

battle of Bosworth Field (Aug. 22, 1485). The victor became king as Henry VII, thus ending the Wars of the Roses. The following year Henry married Elizabeth of York, the daughter of Edward IV, and the white and the red roses were united in the rose of the Tudors, the emblem of a new line of English kings.

THE HOUSES OF LANCASTER AND YORK



The Wars of the Roses broke the feudal power of the nobles and so marked the end of the Middle Ages in England. Many of the ruling nobles were slain in the wars and their estates confiscated by the crown. Lawlessness had torn England since the beginning of the Hundred Years' War and it grew even worse during the Wars of the Roses. Not enough able leaders remained to maintain law and order. It was said that "few would venture alone into the country by day and fewer still into the towns by night." The common people longed for a strong government that would bring peace and prosperity. Henry VII seized the opportunity to re-establish the royal power and to launch policies that marked the beginning of modern England. (*See also* Lancaster; Tudor; and articles on the individual rulers named above.)

ROSS, Betsy (1752–1836). No one knows who actually made the first official American flag. But, according to a tradition which began in 1870, Betsy Ross is given credit for having done so. The story goes that in June 1776 Gen. George Washington, accompanied by Col. George Ross and Robert Morris, came to her Philadelphia shop. General Washington asked her to make a flag from his rough pencil sketch. She suggested a few changes, including the use of a five-pointed star rather than a six-pointed one, and proceeded to carry out the commission.

Betsy Ross was a real person and she did make flags for the government. Very likely she made the so-called Cambridge flag, or the Grand Union flag, which was raised at Somerville, Mass., as the flag of the Continental Army on Jan. 1, 1776 (*see* Flags).

The story of how Betsy Ross sewed the Stars and Stripes was first made public by her grandson, William Canby, in 1870. He said he had heard the story directly from his grandmother. Other descendants said the same. But historians have been unable to verify the claim. Despite intensive search in all historical records, they have found no connection between Betsy Ross and the first flag. But in keeping with the popular tradition, Betsy Ross's home at 239 Arch Street, Philadelphia, is preserved as the birthplace of the American flag. Some historians claim, however, that her actual home was some distance away.

The Known Facts About Betsy Ross

Elizabeth (Betsy) Griscom Ross was born Jan. 1, 1752, in Philadelphia. Her father, Samuel Griscom, was a builder. Her parents were members of the Society of Friends (Quakers); and for a time Betsy attended a Friends' school. Then she became a seamstress in an upholstery shop. Working in the shop was John Ross, the son of an Episcopalian minister. On Nov. 4, 1773, the two eloped to Gloucester, N. J. Because she was married "out of meeting," Betsy was disowned by the Friends. She later joined the Society of Free Quakers.

On their return to Philadelphia, John Ross opened his own upholstery shop on Arch Street. Like many patriots, he served in the local militia. One night in December 1775, a store of gunpowder which he was guarding exploded. Ross was severely wounded and died Jan. 21, 1776. Betsy continued the shop alone.

DID THIS MEETING TAKE PLACE?

According to tradition, Betsy Ross made the first Stars and Stripes. Here she shows General Washington how a five-pointed star would look better than one with six points. Historians are unable to confirm the tradition.

On June 15, 1777, Betsy married Joseph Ashburn, first mate of the brigantine *Patty*. They had two children. Several years later, his ship was captured by the British and Ashburn was sent to Old Mill Prison in Plymouth, England. He died in prison on March 3, 1782, again leaving Betsy a widow. John Claypoole, Ashburn's cellmate, brought Betsy the news of her husband's death. Claypoole had recently been exchanged as a prisoner of war. Betsy married Claypoole May 8, 1783. They had five daughters. After Claypoole's death in 1817, Betsy lived with a daughter in Philadelphia. She died Jan. 30, 1836. Her shop was kept open until 1857.

ROSSETTI, CHRISTINA GEORGINA (1830–1894). Love of nature, understanding of children, and simplicity won Christina Rossetti a high place among 19th-century poets. Children, as well as adults, enjoy and love such lines of her lyric poetry as these:

> Who has seen the wind?
> Neither you nor I:
> But when the trees bow
> down their heads,
> The wind is passing by.

Christina was born in London Dec. 5, 1830. She was the youngest of the four children of Gabriele Rossetti, a political refugee from Italy. All these children became famous. Maria Francesca, as a writer; Dante Gabriel, as a poet and painter; William Michael, as a critic; and Christina, as a poet.

Christina was lively, clever, and rather precocious. Like the other Rossetti children, she got most of her education at home, where she met exiled politicians, artists, and literary men. Her first verses, written when she was 12, were privately printed by her grandfather. At 19 some of her poems were printed by her brothers in *The Germ*, the magazine of the Pre-Raphaelite Brotherhood.

But general recognition did not come until 1862, when her 'Goblin Market, and Other Poems' was published. 'The Prince's Progress' was published four years later. In 1872 appeared the delightful collection of her earlier writings for children, 'Sing-Song'. Her later works in prose and verse were mostly religious. She died Dec. 29, 1894.

Christina Rossetti's poetry was remarkable for its singing quality. It was often inspired by her religious scruples and her strong sense of duty. She was sometimes melancholy and even bitter because of poor health and two unhappy love affairs. Her poetry is sometimes obsessed with death-thoughts. Yet she was often sprightly and fanciful. She was beautiful in a grave manner and was the model for many paintings by her brother Dante and his artist friends.

ROSSETTI'S 'JOAN OF ARC'

Rossetti's young French heroine shows a technique seen in many of his paintings of women—a thoughtful face, a long, graceful neck, and long, dark hair.

ROSSETTI, DANTE GABRIEL (1828–1882). Equally gifted as painter and poet, Dante Gabriel Rossetti was the leading figure in the Pre-Raphaelite Brotherhood. He was the author of such well-loved poems as 'The Blessed Damozel', 'Jenny', 'Sister Helen', and 'The House of Life' sonnets.

He was born in London May 12, 1828, two years earlier than his sister Christina (*see* Rossetti, Christina). Like her, he showed his talents early. When he was five years old he wrote a drama, and at about 16 he wrote a story which was privately printed by his grandfather. After attending King's College School for a few years, he began to study art. School routine irked him, however, and to the end of his life his drawing was faulty. He was strongly influenced by Ford Madox Brown, then a rising young painter. Rossetti worked in Brown's studio for a time.

The Pre-Raphaelite Brotherhood

When he was about 20, Rossetti became closely associated with Holman Hunt and J. E Millais. These three young artists formed the Pre-Raphaelite Brotherhood. The name indicated their intention to return to the directness and truthfulness of medieval art before the days of Raphael. Other artists and writers later became associated with the movement. Edward Burne-Jones, William Morris, Algernon Swinburne, and Rossetti's sister Christina were among them. Rossetti encouraged the others to express themselves both in painting and poetry as he did. His most famous poem, 'The Blessed Damozel', appeared in *The Germ*, a magazine of the Pre-Raphaelite group. He never grew tired of reworking this poem, for revision after revision of it appeared later.

In 1860 Rossetti married Elizabeth Siddal, a beautiful milliner's assistant. She sat as the model for many of his paintings. Not quite two years later she died. Agonized with grief, Rossetti had the only manuscript of his poems (as yet unpublished in book form) placed in her coffin. In 1869, however, he had the coffin unearthed and the poems taken out. Their loss to literature would have been great, but many people found his act hard to forgive.

Rossetti's canvases are remarkable for their glowing color and mystical beauty, but he was a surer artist in his poems. In his early years he was influenced by Shakespeare, Scott, Byron, and the Bible. Then came Shelley, Mrs. Browning, the older English and Scottish ballads, and Dante. Rossetti's own poetry is full of richness. Exaggerated language is a frequent fault; but his wealth of imagery is almost unrivaled.

Some of Rossetti's best-known paintings are 'Ecce Ancilla Domini' (Behold the Handmaiden of the Lord), 'Paolo and Francesca', 'Dante's Dream', 'Borgia', and 'Proserpina in Hades'. Much of his best poetry, including the famous sonnet-sequence 'The House of Life', is found in 'Ballads and Sonnets', published in 1881.

ROTHSCHILD FAMILY. For most of the 19th century, the House of Rothschild, a Jewish family of bankers, ruled the money markets of Europe. From the Rothschilds many European nations borrowed money to pay their debts, to carry on wars, or to finance vast peacetime projects.

Meyer Amschel Rothschild (1743–1812) laid the foundation of the family fortune. He was born in the ghetto (Jewish quarter) of Frankfort-on-the-Main, in Germany. There he set up shop as a tradesman and money-changer, as had many generations of Rothschilds. The family's name was derived from the red shield (German, *rothen Schild*), which an ancestor had used as the sign of his shop. As an expert in rare coins, Meyer Amschel was admitted to many wealthy homes, notably that of the Elector William of Hesse-Cassel. Soon he was entrusted with some of the elector's important financial affairs. In the meantime he trained his five sons to work as a team.

The Rothschilds owed their rise as international bankers largely to the Napoleonic wars. Meyer Amschel's third son Nathan (1777–1836) had gone to England about 1800, and he ran goods through Napoleon's blockade at great profit. He also carried out, with his brothers' help, a clever plan to get gold through France to finance Wellington's army in Spain. This won Nathan a post as agent of the British treasury. At the close of the war the House of Rothschild was commissioned to handle loans to France and Austria.

Nathan's brother Jacob, or James (1792–1868), set up a bank in Paris, and his brother Solomon (1774–1826), a bank in Vienna. Another brother, Karl (1788–1855), later established a bank in Naples, but this was discontinued about 1861. The eldest brother, Anselm Mayer (1773–1855), remained in charge of the business at Frankfort.

The House of Rothschild flourished through the 19th century. Its branches financed European wars and railroads in Europe and America. They took part in loans to the United States in 1871 and 1895. Nathan's son Lionel (1808–1879) in 1875 lent the money which Disraeli used to buy control of the Suez Canal. Lionel was the first professing Jew to be elected to Parliament, and his son Nathan Meyer (1840–1915) was the first Lord Rothschild.

The Frankfort branch was given up in 1901, after the death of the last male member of the family living in Germany. The second World War brought about dissolution of the Viennese and French branches.

ROTTERDAM, NETHERLANDS. The first commercial port of the Netherlands and its second largest city is Rotterdam. It lies 15 miles inland on the Lek River, one of the branches of the Rhine. It provides the chief outlet to the North Sea for the complex Maas-Rhine river system with its network of canals.

Settlement began here in feudal times, and the town was granted municipal rights by John I, count of Holland, in 1299. It grew with the expansion of Dutch foreign trade. Miles of wharves and warehouses were built south of the river to handle the transfer of ocean freight to canal barges destined for industrial centers of Holland, Germany, and Belgium. North of the river, beside tree-lined canals, were the buildings. Around the Groote Kerk ("great church"), the old town hall, and other picturesque reminders of the past were built modern stores, apartments, and commercial buildings.

Over this city on May 14, 1940, swept a cloud of German planes. The Dutch army had already surrendered, but the Germans wanted to spread through Europe fear of their air power. In less than three hours the heart of Rotterdam was erased, with 30,000 people dead in the ruins. Later, while the Germans were using the port, the shipping district south of the river was often attacked by Allied bombers. Before the Germans surrendered on May 4, 1945, they smashed most of the remaining port installations.

Shipbuilding is Rotterdam's leading industry. Its other important manufactures include sugar, cigars, margarine, paints, rope, furniture, and leather goods. Population (1947 census), 646,248.

HOW ROTTERDAM SUFFERED FROM WAR

Here is the old commercial center of Rotterdam, after the second World War. The railway station (upper left) stood in a wasteland after the Nazi bomb raid of 1940.

ROUND TABLE. To prevent his knights from quarreling over rank, the great King Arthur of Britain had them sit around a table without head or foot—the famous Round Table. These knights made up the valiant Order of the Round Table. No one knows when the legend of the table originated. It appeared in stories written by the Normans about Arthur after they had conquéred England. But these stories were based on old Celtic tales which may have first been told when the Romans still ruled Britain.

According to one version of the legend, the table was made for Arthur himself. According to another version it was made by Merlin for Uther Pendragon. Then after passing through other hands, it came into Arthur's possession with the dowry of his queen, Guinevere. The legends differ as to the number of knights. Some place the figure as low as 50, and others increase the number that the table would seat.

Noted Champions of the Round Table

Only the best and most valiant knights were worthy of a place at the Round Table. Each chosen knight had his own seat with his name carved upon it. The members formed a brotherhood bound by oath to help one another in danger and to refrain from fighting among themselves.

In the company were brave Sir Perceval de Galis, one of the men that most believed in Christ; Sir Lancelot, beloved by the fair Elaine of Astolat, and Sir Bors de Ganis, his cousin. Sir Gawaine, Sir Gareth of Orkney, and Sir Gaheris were brothers, and nephews of King Arthur. Sir Tristram (or Tristan) of Lyonesse was the best huntsman of the world and the noblest blower of a horn. Sir Kay was the seneschal of King Arthur's court. Sir Ector de Maris was cured of his wounds by the Holy Grail. The traitor Sir Modred usurped the throne and tried to wed Queen Guinevere, but was killed in combat with King Arthur. The noble Sir Bedivere received the last commands of the king and became a hermit after Arthur's death. Sir Lamorak de Galis, Sir Sagramore le Desirous, Sir Palamides the Saracen, and Sir Bleoberis were among the other brave and noble knights.

One seat, however, known as the "Seat Perilous," had no name upon it. It was reserved for him who should succeed in the search for the Holy Grail—the mystic cup from which Christ had drunk at the Last Supper. The seat was filled at last by Sir Galahad, the perfect knight. Tennyson tells many of the stories of the Round Table in his 'Idylls of the King'. (*See also* Arthur, King; Galahad.)

ROUSSEAU (*ru-sō'*), JEAN JACQUES (1712–1778). The famous French philosopher Rousseau gave better advice and followed it less than perhaps any other great man. He wrote glowingly about nature, yet spent much time in crowded Paris. He praised married life and wrote wisely about the education of children, but he lived with his servant and abandoned their babies. He taught hygiene, but lived in a stuffy garret. He preached virtue, but he was far from virtuous. Rousseau was indeed a strange vessel for all the wisdom he contained. But his writings on politics, literature, and education have had a profound influence on modern thought.

Of French Huguenot descent, Rousseau was born at Geneva, Switzerland, on June 28, 1712. His father was a watchmaker. He grew up undisciplined and at about the age of 16 he became a vagabond. He roamed through Switzerland, Italy, and France, earning his way as secretary, tutor, and music teacher. When he came to Paris in 1741 he was impressed by the fact that society was artificial and unfair in its organization. It lived by rules made by the aristocracy and was little concerned with the common man.

This unknown wanderer upset that whole elaborate society. After years of thought he wrote a book on the origins of government, 'The Social Contract', teaching that no laws are binding unless agreed upon by the people. This deeply affected French thinking and it became one of the chief forces that brought on the French Revolution about 30 years later.

An Influence on Modern Education

Rousseau helped bring about another revolution in education. In his book 'Émile' he assailed the way children were schooled. He urged that they be given freedom to enjoy sunlight, exercise, and play. Rousseau recognized that there are definite periods of development in a child's life. He argued that his learning capacities should be fostered only as the child felt the need. A child allowed to grow up in this fashion would achieve his best possible development. Education should begin in the home. Parents should not preach to the child but should set a good example. Rousseau believed that children should make their own decisions.

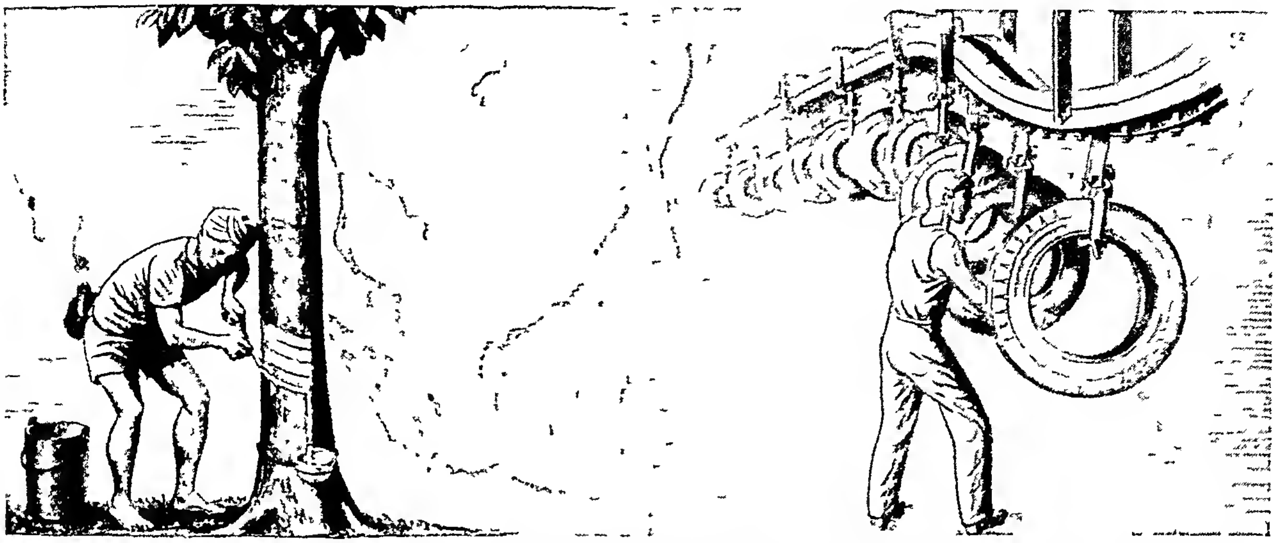
In literature too Rousseau inspired a profound change. He stirred writers to realize that the beauties of nature had a rightful place in literature. The Romantic movement in Germany, France, and England stems largely from Rousseau's influence and examples. He dared to write of his most intimate emotions. His autobiographical 'Confessions' is considered a masterpiece of honest self-revelation.

Rousseau was persecuted for his religious views and fled France in 1762. For a time he lived with the historian David Hume in England. He later returned to France, broken in health and spirit. He died near Paris, a prey to unhappy delusions, on July 2, 1778.

Careful readers of Rousseau find many flaws in his logic, especially in his greatest book, 'The Social Contract'. Rousseau had a large enough mind to realize that his was not the final word on government. "I ought throughout to have kept to a more limited sphere," he admits at the close of his book. Still, this genius was an eloquent prophet of modern democracy, and some of his precepts helped to guide the founders of American democracy.

Rousseau's chief works are: 'La Nouvelle Héloïse' (The New Héloïse), 1761; 'Le Contrat Social' (The Social Contract), 1762; 'Émile', 1762; and his 'Confessions' (an autobiography, written between 1766 and 1770, published in 1782 and 1789).

The STORY *of* NATURAL *and* MAN-MADE RUBBER



Natural rubber comes mostly from plantations in the hot, steamy lands of the Far East. Its most important use in the United States is in the manufacture of tires and inner tubes. Millions of these are needed to keep our transportation system rolling.

RUBBER. No other common substance has the ability of rubber to bend and stretch so much and then snap back into shape. Modern transportation would be impossible without it. Automobiles, trucks, buses, ships, and airplanes use thousands of products made from natural or synthetic rubber. These serve to cushion shock, soften blows, dampen vibrations, transmit power, and perform many other tasks. Rubber tires and inner tubes allow huge loads to be supported on a cushion of air. Without such pneumatic tires, highways would soon be destroyed and vehicles would knock themselves to pieces.

In industry too rubber plays a key part. Factories, mills and mines all use great numbers of rubber products. Among the most important are continuous conveyer belts. Often having cleats attached at regular intervals, these move raw materials and parts to assembly points and finished products to warehouses. In mines or on big construction jobs, belts haul tons of coal, dirt, or ore up out of the earth or across level ground.

The Rubber Plantation

MOST of the world's natural rubber comes from the rubber tree, *Hevea brasiliensis*, originally a native of Brazil. The inner bark of this tropical tree secretes a milky fluid called *latex*. It is from latex that rubber is made. Many other tropical and semitropical plants contain similar fluids but these vines, shrubs, and trees are of little economic importance. Among them are the guayule of Mexico and the southwestern United States, and the *Ficus elastica* of Asia (the ordinary household "rubber plant"). Certain varieties of plants contain a latex that produces other forms of rubber, such as gutta-percha, balata, and the chicle for chewing gum.

The Far East produces 95 per cent of the world supply of natural rubber. Indonesia produces almost half of the total and Malaya about a third. Other countries of southeast Asia—Ceylon, India, Burma, French Indo-China, Thailand, and Borneo—account for most of the rest. Small amounts of rubber come from Africa, mostly from an American plantation in Liberia. Brazil produces some rubber, but not enough for export.

Hevea trees grow best within 15 degrees of the equator. They flourish in the lowlands but still produce at altitudes up to 1,500 feet. For best results they must have at least 75 inches of rain well distributed throughout the year.

A YOUNG RUBBER TREE

Bud-grafted trees produce the most rubber. Here the old top has been cut away, and the young graft will become the new trunk.

On a big rubber plantation, young trees are grown in a nursery and later transplanted to groves. The best trees are produced by *bud grafting*, as are fruit trees and rose bushes. Seedlings are grown in nursery rows to provide rootstocks. When a seedling is one year old, a bud from a high-yielding tree is grafted to it under a flap of bark. The branch from this bud becomes the trunk of the new tree and the old top is cut away. This practice assures the best possible yield from a rubber grove.

Trees are set out during the rainy season in groves of about 150 trees to the acre. The trees grow quickly, shooting up six to

NATIVE WORKERS TAP THE RUBBER TREES;

In the hot lands of the Far East, workers start tapping rubber trees early in the morning.

The tapper shaves off a thin strip of bark, and latex starts flowing slowly.

Three or four hours later the latex is collected and carried away in pails.

nine feet a year and increasing their girth three or four inches a year.

Collecting and Curing Rubber

When a rubber tree is six years old, it is about six inches in diameter and is ready to be tapped for latex. A worker, using a U-shaped gouge, carefully cuts away a strip of bark about one quarter of an inch deep. He makes the cut on a slanting line halfway around the tree some three or four feet from the ground. The cut goes through the outer bark to an inner layer containing the latex system. The latex tubes spiral upward around the trunk. The slanted cut opens many tubes and allows latex to run down the channel of the cut to a spout and into a small cup.

Later cuts are thin shavings about 1/16 of an inch thick, taken from the surface of the channel. Trees are usually tapped every other day, and so the channel is lowered about one foot a year. When the channel is within a foot of the ground, the other side of the tree is tapped while the bark on the first side renews itself. In about six years the bark is renewed and the tree can be retapped with as good a yield as before. A tree reaches its maximum production of latex when about 12 years old. It will produce well for at least 25 years. Trees from ordinary stock give two to three pounds of latex each year, but trees from the best bud-grafted stock yield up to 30 pounds a year.

On the tropical plantations of the Far East, the rubber gatherers set out on their rounds early in the morning. Some are paid workers employed on huge estates owned by Europeans, but a great many are small grove owners who grow their own rubber. Arriving at the first tree, the worker peels a strip of coagulated latex from the old cut and makes a new cut with a sharp chisellike tapping tool. After putting a few drops of ammonia or some other chemical fluid in the cup to keep the latex from coagulating, the worker goes on to the next tree. In three or four hours the latex has stopped dripping, and the tapper goes back to collect the juice from each tree. He usually finishes his work by midmorning.

On an estate plantation, the buckets of latex are taken to the factory, where latex is coagulated and changed into a commercial form of rubber. A small farmer makes commercial rubber in the same ways, but with simpler and usually more primitive equipment.

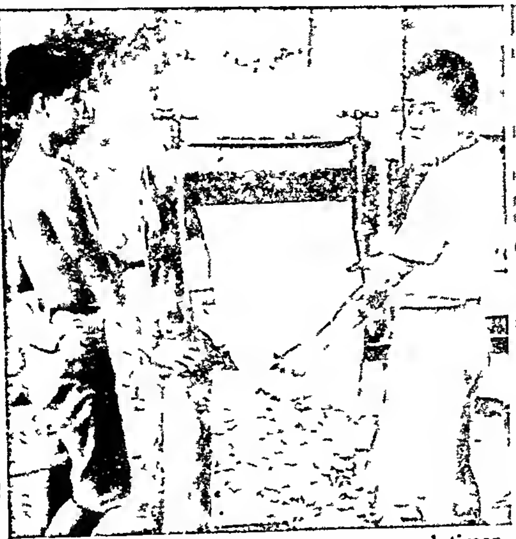
To coagulate latex, a worker dilutes it with water and adds a certain amount of formic or other acid to the solution. Latex as it comes from the tree is a complex mixture of liquids in which tiny pear-shaped particles of rubber are suspended. The mixture is a typical colloid (*see* Colloids). The acid bunches the rubber particles together on top of the watery serum in which they are held. Coagulation takes several hours and results in about one pound of pure rubber for every three pounds of latex.

The slabs of coagulum are then run through rollers which press the remaining water from them. For *pale crepe*, one commercial form of rubber, the coagulum is run through a succession of rollers which convert it to thin, smooth sheets. These are air dried for about three weeks. For *smoked sheets,* the major commercial form, coagulum is rolled into ribbed sheets about an eighth of an inch thick. These are hung in a smokehouse and after three to six days, the wood smoke has made them translucent and amber-colored. The rubber is finally folded and pressed into bales of 200 to 250 pounds for shipment. Most rubber is now shipped "bareback" in uncovered bales, though some goes in burlap-covered bales.

Some rubber, about 5 per cent of the total, is shipped in the form of *concentrated latex*. About two thirds of the serum is removed from the raw latex either by centrifuging or by chemical processes. Ammonia is added to the concentrated latex to keep it from coagulating and it is shipped in liquid form. Most of the rubber of all kinds shipped to the United States enters at the ports of New York City, Baltimore, Mobile, New Orleans, and Los Angeles.

CURING THE RUBBER WITH CRUDE EQUIPMENT

Latex is poured into pans and then coagulated with a little formic acid.



Slabs of coagulated latex are run several times through a wringer to make pale crepe rubber.

Most commercial rubber is smoked for several days before it is baled.

Manufacture of Rubber Products

THE CENTER of the rubber-manufacturing industry in the United States is the city of Akron, Ohio, often called "America's rubber capital" (*see* Akron). Principal products of this industry are tires and inner tubes. About three quarters of all rubber goes into them.

At a rubber factory the bales of plantation rubber may first be cut in pieces with a bale cutter. Then the rubber is broken down and softened in a mill. This is usually done in a banbury internal mixer, which consists of rotating knives inside a closed barrel. A banbury is a powerful machine and can break down a 750-pound batch of crude rubber in less than four minutes.

The broken-down rubber returns two more times to the banbury for further mixing. For making tire treads a large amount of carbon black (30 per cent by weight) is mixed with the rubber. Carbon black helps the tread to resist abrasion. Mineral oils are also added to soften the rubber. The stock after processing is extruded like toothpaste. In final mixing, the rubber is returned to the banbury and various chemicals are added. The most important of these is sulfur, which is necessary for vulcanizing. The stock is well blended and then sent to an automatic mill.

This mill consists of two hollow rollers rotating toward each other. The rollers turn at different speeds and so knead the rubber between their surfaces. Water or steam can be circulated through the rollers to cool or heat them. The stock comes from the automatic mill in the form of a ribbon of soft rubber.

Making an Automobile Tire

A tire is made up of two principal parts, the inner *carcass* and the outer *tread slab*. The carcass gives strength and flexibility to the tire, enabling it to carry heavy loads. The tread slab, which includes the rubber sidewall as well as the tread, protects the carcass from the weather, provides traction, and gives resistance to wear.

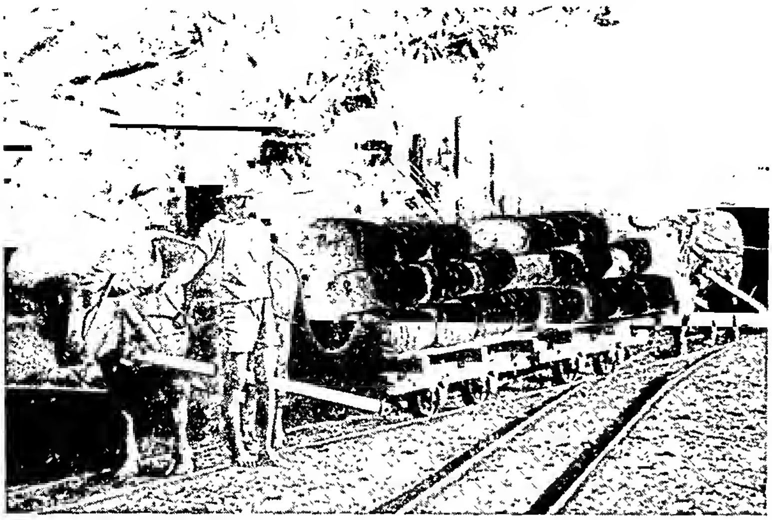
Stock for the carcass is prepared on a calendering machine. It is similar to a mill but has more rollers. The calendering machine, or calender, forms a continuous sheet of thin rubber. For carcass stock, rubber and cloth fabric are fed to the machine at the same time. The calender then squeezes, or "frictions," the soft rubber into the fabric, producing a single *ply* of rubber-coated fabric. Before the fabric goes to the calender, it usually has been treated with liquid rubber. This assures that the rubber and fabric will be firmly bound together in the ply. Such treatment is particularly important with rayon or nylon fabrics. Unlike the ordinary cotton tire fabric, these are made up of smooth filaments which are hard to coat with rubber.

Stock for the tread slab is made on other machines. These machines force doughy rubber through an extruder which forms it into a thick, flat ribbon. Tread and sidewall may be extruded separately and then joined together or the same machine may form them as one piece. For white sidewall tires, the sidewall must be formed separately.

Another part of the tire is the *bead*. In the finished tire the beads are thickened edges which fit next to the rim. They join the carcass and sidewall and provide a rigid base for the tire. Stock for the bead is built around steel wire of great strength. The wire is covered with rubber and enclosed in a fold of plain-woven cloth fabric.

The tire is finally built up from these stocks on a tire-building machine. Fabric-and-rubber *plies* come to the machine cut on the bias to the proper length and width. Tread slab and bead stock are also cut to length for particular sizes of tires. The tire is built on a drum-shaped core. The worker wraps plies around this drum one by one, building up the carcass of the tire. Then he fastens the beads in position at the outer edge of the carcass and applies the tread and sidewall. When the tire is slipped from the machine, it looks like a big, round napkin ring.

BALES OF RUBBER GO TO MARKET



From remote plantations in many parts of the Far East, bales of crude rubber are still shipped to market on primitive, ox-drawn flatcars. After arriving at the market town, the rubber will go to the United States or Europe.

In the next operation it takes on more the look of a tire. An air bag, which looks like a very heavy inner tube, is placed inside the "green" tire, and the tire is squeezed and flattened into shape around the bag. It is then put in a watchcase curing mold, which consists of two halves hinged together like a waffle iron. Each side of the mold contains half the tread and sidewall design. The mold is closed and heated, and the air bag is inflated. Pressure of the air bag forces the rubber, softened by heat, into every corner of the mold. This action impresses the maker's own pattern on the tread of the tire.

As the temperature rises to about 300° Fahrenheit, the rubber *vulcanizes*. In vulcanization the sulfur, which was added in an early operation, joins chemically with the rubber. This toughens and strengthens the rubber, enabling it to stand great cold and heat without softening or becoming brittle. In some factories tires are finished and cured in combination machines such as the Bag-O-Matic. The tire is placed in position without an air bag. The machine automatically shapes it with its own air bladder and then, when closed and heated, completes the cure.

The inner tube for a tire is manufactured somewhat differently. The rubber stock is extruded in the form of a cylinder, or large hose. This is cut in proper lengths, the tube valves are inserted, and the ends are spliced together into a doughnut shape. The green tube is then inflated and vulcanized with steam. Puncture-proof tubes are made by adding a gummy, plastic layer to the inside surface of the tube. When a nail punctures the tube, this *sealant* flows around the nail and prevents loss of air. Even when the nail is removed the tire keeps its air, for the sealant fills the hole completely.

Wide Range of Rubber Products

The rubber industry manufactures a wide variety of products. Besides automobile tires, it produces truck, tractor, airplane, bicycle, motorcycle, and solid tires. After these transportation items, the next large category includes rubber footwear of all sorts.

Nearly all rubber products are vulcanized. Sulfur is added to the mixed rubber in varying quantities according to the type of the product. The greater the amount of sulfur added, the stiffer is the resulting rubber. A mixture of rubber and sulfur must be heated to complete the vulcanization, and because of the varied nature of rubber products several different methods are used to accomplish this.

Rubber boots and all-rubber overshoes are shaped and vulcanized on perforated metal or wooden lasts. They are usually placed in molds heated with steam for curing. The same procedure is used to manufacture rubber heels and soles, hot-water bottles, and bathing caps.

Other products, such as rubber rings for jars, air-brake hose, and some boots and shoes are vulcanized by direct steam cure. They are placed in a closed iron cylinder, often wrapped in wet cloths, and live steam acts directly on the articles. In the air-cure process, articles which might be damaged by steam, such as rubberized woolen cloth, are heated by warm air.

Making Hose, Tennis Balls, and Other Products

Garden hose is built up in layers somewhat as a tire is built. In this case, however, all the operations are automatic. The inner layer is forced out of an extruder machine in the form of a tube. Then a braiding machine covers the tube with one or more layers of cotton or nylon fabric. If two or more fabric layers are used, they are separated by a layer of thin calender rubber. Finally, in another extruder, the outer layer of colored stock is applied to make the finished hose. For the vulcanizing process, the hose is filled with water or air under pressure and inserted in a lead sheath. This is then heated until the cure is complete.

To make a tennis ball, four segments of rubber are sewed together, with a small disk of pure rubber and a few drops of water inside. Then the ball is heated in a mold to cure it. The heat also changes the water into steam and this forces the ball tight against the mold. Next, compressed air is shot into the ball through a hollow needle, at the point where the disk is attached inside. When the needle is pulled out, the disk expands and plugs the hole. Finally the flannel covering is cemented on.

Rubber belting is made from rubber-impregnated (frictioned) fabric. The fabric is folded and rolled, two plies at a time, until the belt is built to the desired thickness. Then the belting is cured in a heated hydraulic press. Small rubber hose, channel rubber for automobile windows, and similar products are made in molding machines. The best rubber gloves, such as those used by surgeons, are now made

by dipping forms into latex compounds. These and other similar products are of better quality than those made by an older process of dipping into dissolved rubber.

Hard and Special Rubbers

Hard rubber contains a large amount of sulfur, usually from 30 to 50 per cent. It is used in the chemical industries for vats and other containers because it resists attack by most chemicals. A tough rubber coating for vats can be deposited electrically from a solution of latex, sulfur, and carbon black.

CRUDE RUBBER GOES INTO A MIXING MACHINE

In a rubber factory of the United States, plantation rubber is chopped and softened in a huge machine called a banbury mixer. Here a factory worker is dumping a bag of sulfur on a load of previously softened rubber before running it into the machine.

Colored rubbers are produced by adding pigments. For white rubber, zinc oxide, zinc sulfide, lithopone, or titanium dioxide are used; for black, carbon black; and for red, iron oxide. Except for carbon black, these are inorganic, or mineral, pigments. Organic coloring agents, many of them obtained from coal tar, are used for most other tints, such as green and rose.

Latex products have grown in importance since the second World War. One of the most important of these is *frothed sponge.* Highly concentrated latex, compounded with curing ingredients, is whipped into a froth by beating in air. The frothed latex is poured into molds and quickly cured. The result is a spongy product containing millions of tiny air bubbles. These cells are interconnected so that the sponge "breathes" when it is squeezed and released. Frothed latex sponge is well suited for pillows, mattresses, furniture upholstery, automobile and theater seats, padding of many sorts, and sponges.

Rubber is also used as a raw material in making other materials. Neolite, for example, is a blend of rubber and plastic. It is widely used for shoe soles and heels and for luggage. A rubber paint and rubber-to-metal adhesives are made from Thermoprene, or Pliolite. This is obtained by causing rubber to react with an acid or tin tetrachloride. Pliofilm is a food-wrapping film made from rubber and hydrogen chloride. Making rubber react with chlorine results in a resin called Parlon. This serves as the basis of chemically resistant paints. Rubbone, made in England by oxidizing natural rubber, is used for coatings and cements.

Reclaimed rubber is made from scrap rubber. Oil solvents are added to the scrap and it is heated with steam under high pressure. Reclaimed rubber is used in many products, especially those which do not have to stretch or bend greatly, such as rubber heels and hard-rubber goods.

History of Rubber

CIVILIZED men have known about rubber for centuries, but only for 200 years or so have they made any use of it. Rubber came from the New World to the Old. It was once thought that Columbus was the first European to see rubber. The Hevea tree apparently was never grown on any of the islands visited by Columbus, however, and so it is doubtful that he ever saw the substance. The honor is now given to Cortez and the other Spanish explorers of Mexico. These early explorers reported that the Indians played a game with a bouncing ball made from the dried gum of a tree. The soldiers of Pizarro learned from Peruvian natives to cover footwear and clothing with this waterproof juice. The Indians of Central and South America knew about rubber as early as the 11th century. The natives of southeast Asia also knew of it. From ancient times they used it to make torches and to waterproof baskets and other articles.

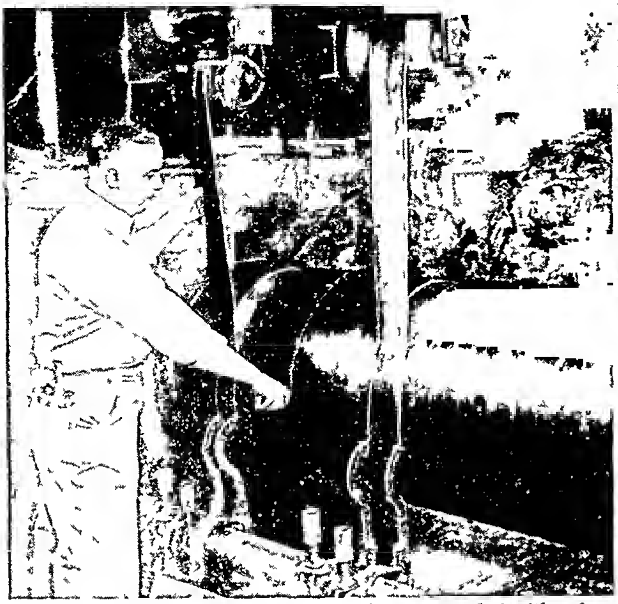
The French scientist, Charles de la Condamine, visited northern South America from 1736 to 1744 and sent the first samples of rubber to Europe. He named it caoutchouc (*ku̦'chu̦k*). In the Tupi Indian language, this word meant "weeping tree." They gave the Hevea this name because the tree gave forth juice so freely that it seemed to be weeping.

Rubber was given its present English name by the British chemist Joseph Priestley. In 1770 a friend in America sent him a ball of crude rubber. Discovering that it would rub out pencil marks, he broke off small pieces and called them rubbers.

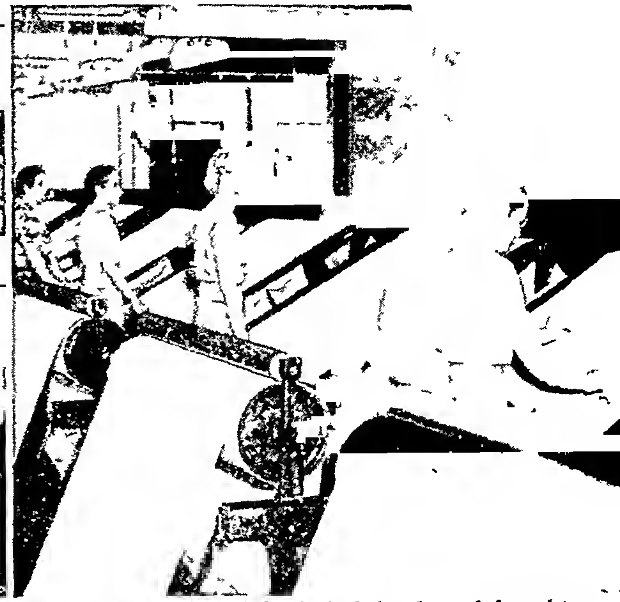
In spite of general familiarity with rubber, it was not considered important until the 19th century. In 1818 the first modern use was discovered by a brilliant 19-year-old British medical student, James Syme. He found that naphtha made from coal tar would dissolve the dried gum and that cloth could be waterproofed by pressing thin sheets of the dissolved gum between two pieces of fabric. Charles Macintosh, a manufacturing chemist of Edinburgh, patented Syme's process in 1823 and made waterproof garments, which were commonly called "mackintoshes."

Pure rubber, however, gets soft, sticky, and has a disagreeable odor in warm weather, while cold makes

IN TIREMAKING, RUBBER AND FABRIC ARE PRESSED TOGETHER,



After the crude rubber has been properly compounded with sulfur and other chemicals, it is kneaded in an automatic mill, leaving this machine as a thick, black ribbon.



Meanwhile, cotton cord fabric is being loomed from latex-coated yarn. Joined with rubber from the mill, it will form the plies for automobile tires.

it brittle. Articles made from it were unsatisfactory until vulcanization was discovered in 1839 by Charles Goodyear, a Connecticut hardware merchant.

The Discovery of Vulcanization

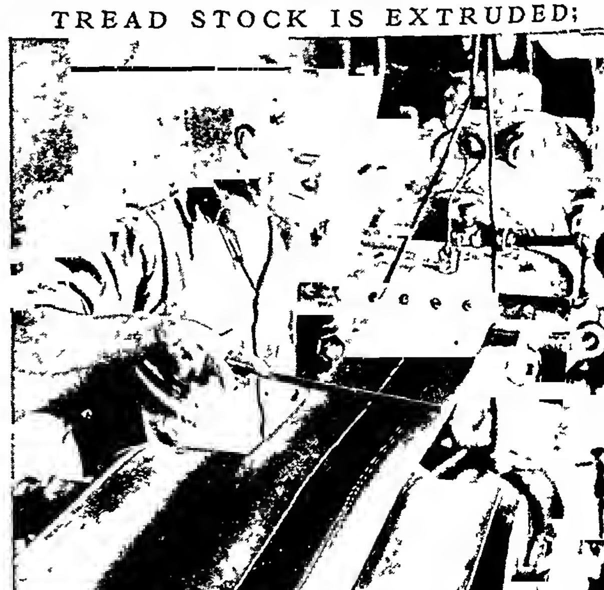
Goodyear got the idea that the defects of rubber might be overcome by processing it with some other substance. In his search for the right substance he became so engrossed that he let his hardware business fail and was jailed for debt. Success came at last partly through accident, when he was displaying a mixture of rubber and sulfur. The piece slipped from his hand into the fire, and when he took it out he found to his amazement that the mass had charred without melting. It was not sticky, and when it was stretched it snapped back into its original shape. He nailed it to the doorpost and in the morning found that the frost had not made it brittle.

Goodyear named this process of combining rubber with sulfur by heat "vulcanization" (from Vulcan, the god of fire). Later he discovered that the addition of zinc oxide made the compound stronger and tougher and that vulcanization could be speeded by adding lime, magnesia, and lead compounds. In 1844 he secured patents for his discovery, and thereafter he was often in court defending his rights. He never gained financial success, but before his death in 1860 he saw his invention put to some 500 uses and give employment to 60,000 persons.

Until the early part of the 20th century, nearly all commercial supplies of rubber came from the forests of the Amazon in South America and the Congo in Africa. Now, as has been seen, virtually all natural rubber comes from plantations in the lands of southeast Asia.

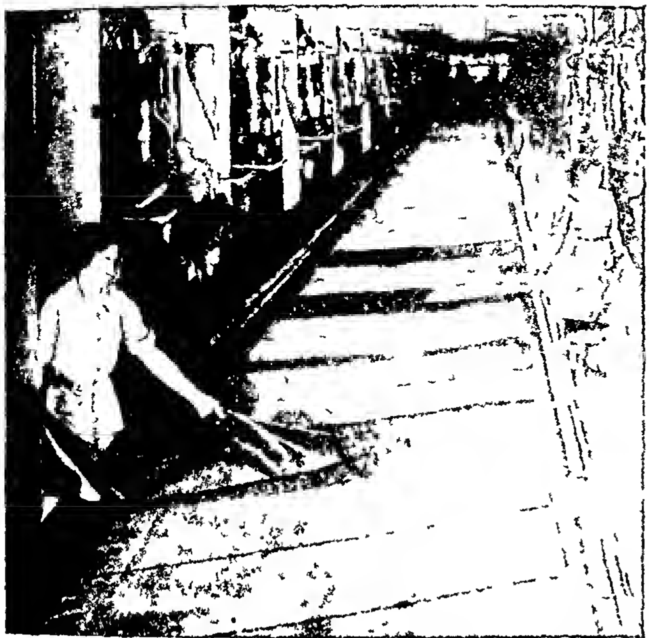
The plantation-rubber industry of the Far East is the result of the work of Henry Wickham (later Sir Henry Wickham), an English botanist, who spent years in Brazilian jungles studying the rubber tree. British officials commissioned him to gather seeds for experimental planting at the famous Royal Botanical Gardens at Kew, England. Wickham took an ocean-going vessel far up the Amazon River and placed on board 70,000 rubber-tree seeds. They had to be gathered and stored under most careful supervision. Their oily covering would lose vitality unless exactly the right conditions were maintained. In 1876 young plants from the Botanical Gardens were sent

TREAD STOCK IS EXTRUDED;



Tread stock for automobile tires is not rolled out, as are the plies. It is extruded in a plastic form from a machine. It will later be cut to exact length for tires.

FORMING CARCASS STOCK



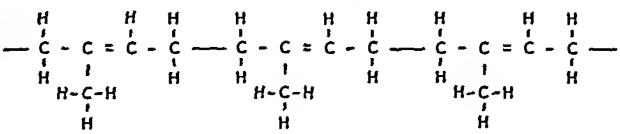
After the sheet rubber and tire fabric have been pressed together in a calendering machine, the finished stock is cut on the bias. *These pieces form the plies of a tire carcass.*

to Ceylon for planting. When the trees prospered there other young plants were shipped to Malaya, Sumatra, Java, and Borneo.

The plantation industry, however, developed slowly until the Brazilians attempted, in 1905 and later, to "corner" the rubber supply. Their operations sent prices soaring, first to \$1.50 a pound and later to \$3.06. The high profits earned by the few British plantations which were then producing rubber gave life to the industry. By 1915 some 3 million acres had been planted in the Far East.

Chemistry of Natural and Synthetic Rubber

NATURAL rubber is known chemically as *polyisoprene.* This means that it consists of many units of *isoprene,* a compound of carbon and hydrogen with the formula C_5H_8. Isoprene molecules are joined to each other in long chains; and each chain forms a multiple molecule, or *polymer,* composed of a number of identical smaller molecules. The number of such units in a rubber polymer may be as high as 10,000 to 20,000. The carbon and hydrogen atoms are arranged in the following fashion in a short section of such a chain:

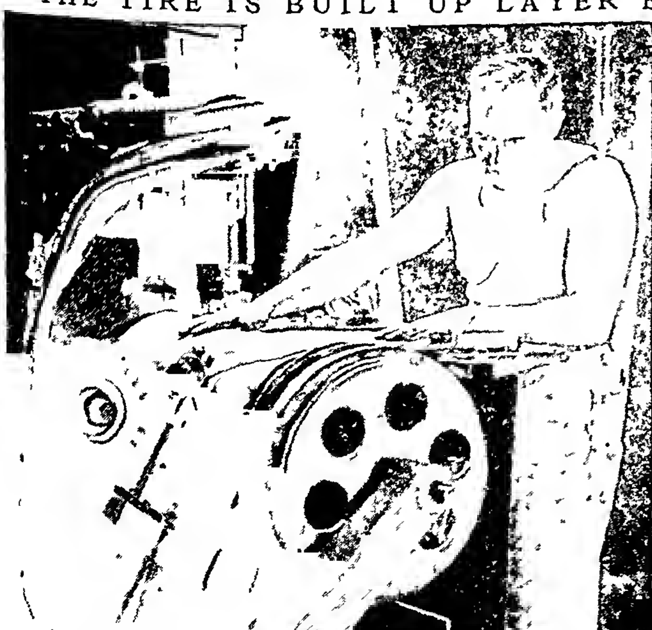


A number of these long chains, in turn, are intertwined to form the pear-shaped particles of pure rubber described earlier. Raw rubber consists of these particles alone, separated from the surrounding watery liquid.

The elastic quality of rubber is not entirely understood. It seems probable, however, that the long molecules of natural rubber are coiled up like tiny springs. When the rubber is stretched the springs straighten out, and when the force is removed they curl up again in their original position.

In its natural state, rubber is not very useful because it is so greatly affected by heat and cold. Rubber did not become really useful until Goodyear discovered how to vulcanize rubber with sulfur. In this process, sulfur atoms form *cross links* between the chain molecules of rubber, tying them firmly together. Natural rubber, greatly magnified,

THE TIRE IS BUILT UP LAYER BY LAYER

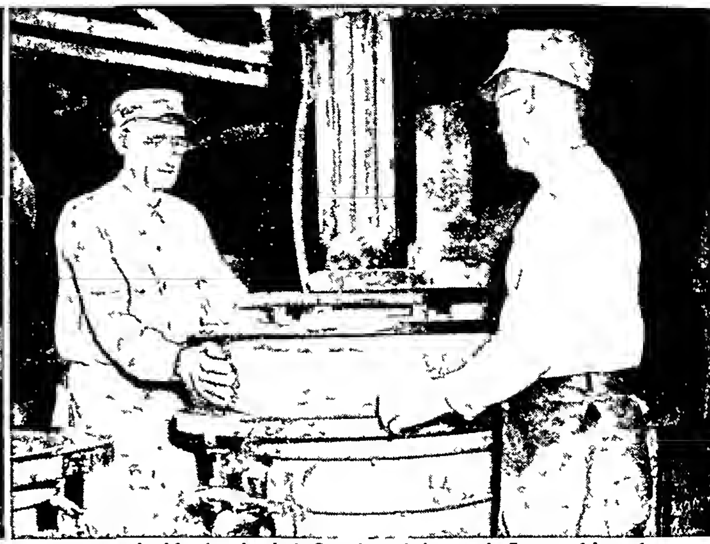


An automobile tire is built around a core on a tire-building machine. The worker *first applies the pieces of ply stock,* smoothing the material and fastening it in place.

After fastening the bead to the plies, the worker attaches the tread slab, which includes the sidewall. The tire is finished, *but it still looks like a circular napkin ring.*

FORMED IN A PRESS AND CURED IN A MOLD,

The green, "uncured," tire is taken from the tire-building machine, and an air bag resembling a big inner tube is placed inside it.



The air bag inside the tire is inflated, and the tire is flattened into shape on the bed of a press Under heat and pressure from within and without the tire takes its form.

probably resembles a tangled mass of cooked spaghetti. After the vulcanization process, the individual pieces are attached to each other in a random fashion, and it is no longer possible to pull one out separately from the others. The reaction between rubber and sulfur is slow and requires high temperatures. It can be speeded up, however, if other compounding ingredients, such as zinc oxide or fatty acids, are used.

The vulcanization process causes some striking changes in the properties of rubber. The rubber remains firm and elastic at both low and high temperatures. Its strength is increased and it can be stretched to greater lengths than before. It will no longer dissolve in gasoline or benzene, though it will swell up if it is soaked in them.

PAVING A STREET WITH RUBBER

Rubber today is used for thousands of purposes unknown a generation ago. One of the most novel is its use as paving material. Rubber stands up better and is easier on vehicles than asphalt.

Synthetic Rubber

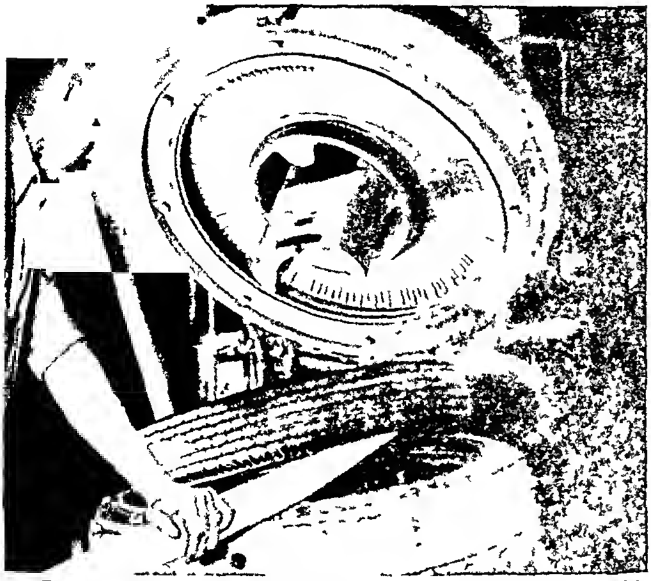
As early as 1860, chemists were attempting to produce rubber synthetically (artificially) in the laboratory. This might appear easy, since raw rubber is composed only of the common elements carbon and hydrogen. To produce rubber, however, these elements had to be linked in special patterns. This proved so difficult that many chemists stopped trying to make exact duplicates of natural rubber. Instead they tried to find other chemical combinations that would provide physical properties similar to rubber. Scores of such *rubber substitutes* (as chemists prefer to call them) have been discovered in the 20th century. No one of them has all the qualities of natural rubber, but some of them are decidedly better than natural rubber for certain purposes.

To make these substitutes, chemists do not begin with carbon and hydrogen. They start with materials in which desirable combinations of carbon and hydrogen already exist. Among these are acetylene, alcohol, and certain compounds (such as butane) derived from petroleum.

Neoprene, Buna, and Butyl Rubbers

In 1925, the Rev. Dr. Julius Niewland of Notre Dame University, while experimenting with acetylene, produced a substance called *vinyl-acetylene*. This aroused the interest of research chemists of the Du Pont laboratories. Working with Dr. Niewland, they produced from this substance another material called *chloroprene*. It proved possible to combine chloroprene molecules into chains and to vulcanize them into a kind of soft rubber that was given the trade name *neoprene*. Neoprene is still widely used in such items as gasoline hose, for which natural rubber is entirely unsuitable.

THE TIRE IS FINISHED



Finally, the tire is vulcanized and finished in a watchcase mold. With the air bag again inflated, the mold is heated and the rubber takes its final form.

In the 1930's, German scientists produced two other synthetic rubbers, buna N and buna S. Starting with butane gas, a simple hydrocarbon, they transformed it into *butadiene,* a more simple hydrocarbon with four carbon and six hydrogen atoms. They found that butadiene, like chloroprene, would polymerize into a rubberlike material. They discovered also that a better rubber resulted if molecules of other substances were introduced as links in the butadiene chain. When molecules of two different chemicals take part in forming a chain, they are said to *copolymerize,* and the product is called a *copolymer.*

The Germans copolymerized butadiene with *acrylonitrile* to form buna N. This vulcanized with sulfur just as natural rubber does. It was resistant to the attacks of oils but proved unsuitable for automobile tires because it built up too much heat on the road. This is true of other synthetic rubbers, and the present practice is to use pure synthetic only for the tread of a tire. Buna S, somewhat more suitable for tires than buna N, was made by copolymerizing butadiene with styrene.

Shortly after the formula of buna N became known, similar rubbers were developed in the United States under various names, including Hycar, Chemigum, Paracril, and Butaprene. At the same time, research in the field of plastics yielded a number of rubberlike plastic substances. Among these were Thiokol, Koroseal, and Vinylite.

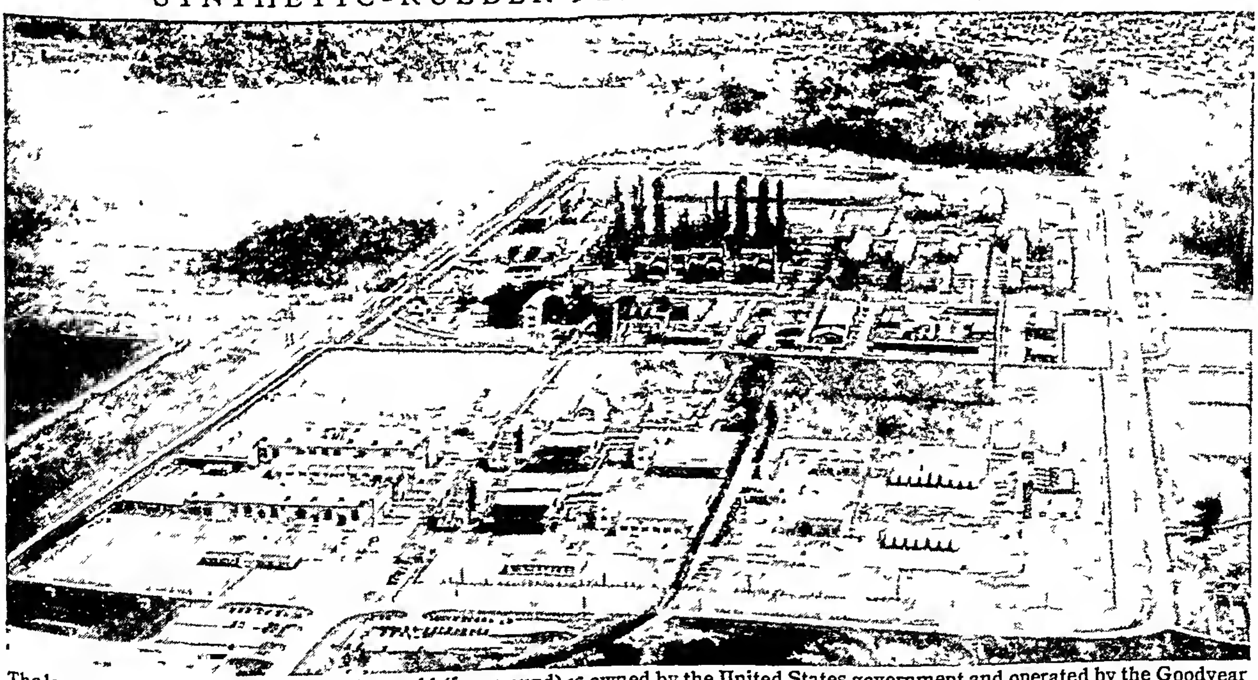
In 1940 the Standard Oil Company of New Jersey announced the discovery of *butyl* rubber. This is made from isobutylene, a petroleum product, which is copolymerized with a small amount of butadiene. Butyl rubber is highly impermeable to air and other gases, and for this reason it has largely replaced natural rubber in inner tubes.

Second World War and After

When the Japanese attacks in the second World War cut off the United States from the rubber of the Far East, the country faced a serious emergency. Rubber for tires and a hundred other purposes is vital in war. Hence the government took drastic steps to conserve existing stocks.

The government worked with Latin American countries to revive their rubber production. It also tried to cultivate in the United States plants that yield a latex similar to rubber latex. The guayule was

SYNTHETIC-RUBBER PLANTS AT HOUSTON, TEX.

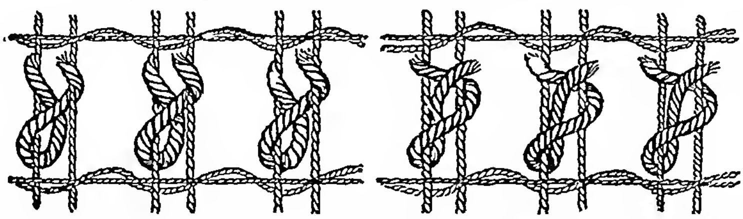


The largest synthetic-rubber plant in the world (foreground) is owned by the United States government and operated by the Goodyear Tire and Rubber Company. Butadiene is produced in the other plant (background), operated by the Sinclair Refining Company.

dyed yarns are left in the sun and rain and wind for weeks until the dye becomes a permanent part of the fibers of the yarn itself. Colors are thus obtained which in softness, brilliance, and permanence greatly excel those produced by the aniline dyes used by some unscrupulous imitators of the ancient weaves.

The rugmaker uses in her weaving two simple implements—a coarse wooden or metal comb and a pair of shears; and the operation of tying the yarn so as to make the rug is so simple as to be almost unbelievable when the finished product is considered. She catches up a bit of yarn, winds it about the two warp threads, ties it tightly, and brings it up through so that the short ends will protrude. These ends are then clipped to give an even surface to the rug.

TWO WAYS OF TYING WEAVERS' KNOTS



These two pictures show two different styles of knots that are used in rugmaking. On the left is the Sehna knot, which is used in many parts of Iran (Persia), and on the right is the Ghiordes or Turkish knot, which is used in Turkey and generally throughout Asia Minor.

Two Knots Used in Rugmaking

There are two ways in which the knots are tied—the Sehna (Persian) knot and the Ghiordes (Turkish) knot. The Sehna knot is really more of a twist. It is arranged to bring the end of the pile yarn through each space between the warp threads. The Ghiordes knot, on the contrary, is more like a real knot. Both ends of the yarn come through together between every two threads of the warp. More knots can be tied to the square inch by the Sehna method, and the pile can be trimmed down more closely, as there are no knots or spaces to conceal. The number of knots to the square inch determines the value of the finished rug. Some of the finest rugs have as many as a thousand knots to the square inch.

Using one or the other of these methods, the rugmaker ties tuft after tuft separately, working out the tedious intricate design with the various colored yarns. After a row has been tied the width of the loom, one or more weft threads are woven across and pressed down tightly above the row of tied tufts with the comb, to make the work solid and fast. It is the slowness of this hand work which accounts in large measure for the costliness of oriental rugs. All classes are represented among rugmakers—men and women, boys and girls, the people of the towns and the wandering nomad tribes. In Iran (Persia), in the Caucasus, and in many parts of Turkey, rug weaving is the main industry. But in recent years many rugs offered for sale as true orientals are of loose weave, careless design, and poor workmanship, and dyed with chemical dyes.

Oriental rugs are usually classed geographically as Persian, Turkish, Caucasian, Turkoman, Indian, and Chinese. Each of these six main divisions has many subdivisions, named usually from the various districts of the country. The rugmakers of a district follow a single general design, which all the families copy and have been copying for centuries with slight variations of colorings or size; but usually each weaver puts a great many personal touches into the rug he or she weaves, so that oriental rugs even of the same district are rarely exactly alike. The rugs of all Mohammedan countries are characterized by their geometric or very highly conventionalized flower and animal designs, as the Mohammedan religion prohibits the representation of any form of life.

Persian Leadership in Rugmaking

The great artistic beauty of Persian rugs and their superior workmanship gave Persia fame as the real home of the oriental rug as early as the 16th century. The country has held its lead ever since. There are at least 14 varieties of Persian rugs. Among them are Khorassan, Meshed, Herati, Shiraz, Kirman, Tabriz, Sehna, Serebend, Teraghan, Saruk, Herez, Hamadan, Sultanabad, and Ispahan. The Shah of Iran (Persia) in his palace at Tehran has a fine collection of antiques. It includes the carpet that belonged to the famous Peacock Throne at Delhi. Persian designs are characterized by a floral pattern.

The geometric design is carried to perfection in the Caucasian rugs, which show star shapes, circles, fretwork, diamonds, triangles, and various forms of the swastika (卐) in bold design. The rugs listed as Caucasian are Daghestan, Cabistan, Chichi, Circassian, Derbend, Kazak, Guenjes, Cashmere, Shirvan, and Karabagh.

The Kurds combine the designs of Persia and Caucasia in five kinds of rugs, known as Persian Kurdistan, Turkish Kurdistan, Sumak, Mosul, and Kelim. The Kelims, as stated above, are without pile and are closely woven in beautiful design and color. They are used as rugs, tent hangings, and blankets.

Among the old Turkish rugs there are some wonderfully beautiful ones—the Ghiordes, Kulah, Bergamo,

THREE KINDS OF CARPET EVERYBODY HAS SEEN

Here are three familiar kinds of carpet. The one on the left is body Brussels. Notice how clear and precise the pattern is. Next is the Wilton, known for its durability as well as its beauty—clean-cut, soft, and luxurious. The third pattern is Axminster, of the "spool" type, which has a loose, soft, and very agreeable texture and is often worked out in elaborate and florid designs.

Direct-color photograph *Courtesy of Pushman Brothers, Chicago*

A JEWEL OF THE WEAVER'S ART

Persian weavers from the province of Kerman made this beautiful rug Although it is modern, it employs all the skill and artistic perfection of the antiques Kerman is a tropical region in southern Iran (Persia), and its weavers use the flowers and colors of the tropics in their designs.

CARDING AND SPINNING WOOL IN ARMENIA

For carding, a comblike device is used, or sometimes a board with nails driven into it. Much of the spinning is done by shepherds while tending their sheep. They take a good supply of wool with them in the morning and, with simple spindles, spin away hour after hour in the sunshine.

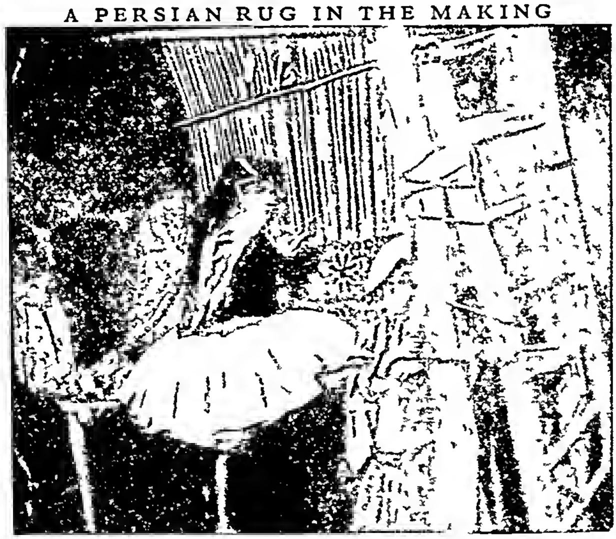
Ladik, Yuruk, Melez, Kir-Shehir, and Turkish Kelim rugs. Turkoman rugs come from Russian Turkestan and are known as Bokhara or Tekke, Khiva or Afghan, Yomud, and Baluchistan weaves. The Bokharan rugs are marked by a beautiful straight-line pattern and their color is rich and harmonious.

Indian rugs are closely woven, heavy, and of attractive colors, and usually have a large center medallion. The manufacture of these rugs is largely in the hands of American and European firms. The large medallion center and smaller border in green, blue, crimson, and yellow are characteristic of this weave. Beautiful silk rugs come from Tanjore, Masulipatam, and Benares.

Chinese rugs are of surpassing beauty, consisting usually of highly conventionalized designs on a solid field of exquisite shades of blue, yellow, red, fawn, gold, or tan. Some of these rival, in sheen and iridescent gleam, the finest Persian rugs.

In the United States the blankets and rugs of the Navajo Indians compare rather favorably with the productions of the Far East. Colored with native pigments, they wear for years. (*See* Arizona.)

A PERSIAN RUG IN THE MAKING

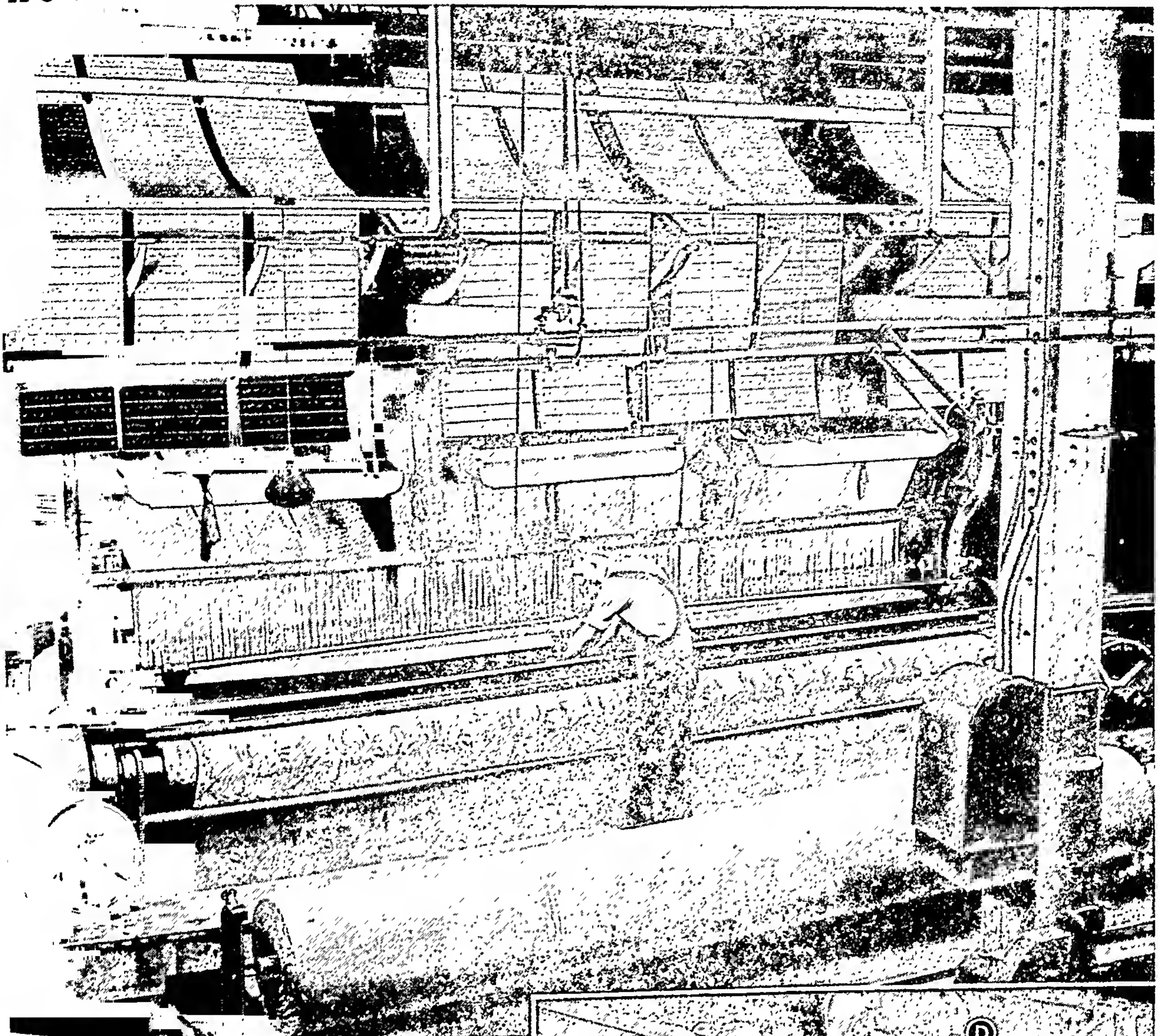


Do you wonder that Oriental rugs are so expensive, when every thread has to be woven in place by hand? This expert weaver is a Kurdish girl in Iran (Persia), wearing the high boots and voluminous short skirts of the national costume.

During the Middle Ages hand-knotted pile rugs were made in Europe in imitation of the imported oriental ones, but owing to the length of time required to make them they could be afforded only by the very rich. The most common floor coverings were ingrains and coarse tapestries, woven on hand looms, and even these were considered luxuries.

Today woven carpets have a considerable use as floor coverings. "Ingrain" carpeting gets its name from the fact that the yarn or "grain" is dyed before weaving. It is made with two colors of yarn, the design appearing in reverse colors on different sides of the fabric. This carpet is now made by machinery and is known as Kidderminster, from the town where it was first made in England, or Scotch, from the place of its origin.

Designs on tapestry carpets were originally made by using many bobbins, each containing a different color (*see* Tapestry). In 1832, however, a method was invented which allowed the patterns to be dyed or printed on a single warp thread before weaving, great care being taken so that the colors came up in exactly the right places in the design.

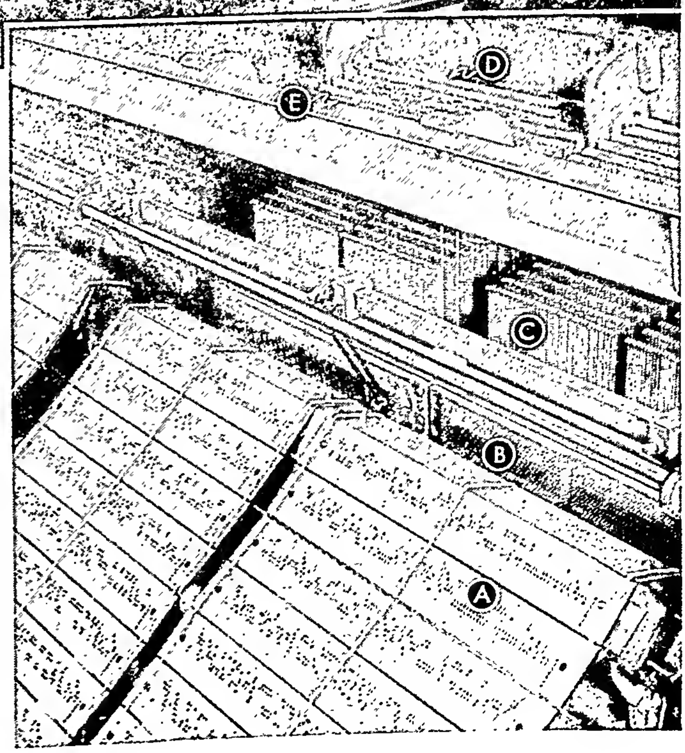


A Huge Jacquard Loom (Top)

The Jacquard is the modern loom for weaving patterns into rugs and other textiles. Those strings from above lift the threads of the warp. Each string is attached to a hook, and the hooks are controlled by perforated cards.

A Close-up View of the Jacquard Mechanism (Right)

The perforated cards (A) roll over a cylinder at the top of the loom, coming in contact with horizontal needles (B) attached to the hooks (C). Needles which do not strike perforations in the cards move backward, carrying their hooks back, out of the way of a rising grate of parallel bars (D). The bars come up under the curved tops (E) of the remaining hooks and lift them. When this picture was taken, the bars were up and the hooks that had not been lifted had sprung back into place. The lifted hooks raise the attached warp threads to form a "shed" through which the bobbin passes the weft thread. Thus the design for the rug is determined by the perforations in the cards.



Hand-woven tapestries and ingrains, however, were flat, having no pile. In the middle of the 18th century a heavy carpet was invented in imitation of floor tapestry, with a thick looped pile made by passing the warp threads over a stout wire which was later withdrawn. Although invented in England this was called Brussels carpet, from the city where tapestry was woven. The figures were formed by warps of different colors that were buried in the body when not wanted on the surface. In carpets of this kind you can usually tell the number of the thicknesses of worsted in the fabric by counting the colors.

Later Wilton carpets were made, in exactly the same manner as Brussels, except that the loops were made over a larger wire, and were cut as the wire was withdrawn. Thus Wilton carpets have a velvet instead of a looped pile. This looped pile method was also applied to the making of tapestry carpets, which, when the loops are cut, is known as velvet carpet. Thus velvet is to tapestry what Wilton is to Brussels.

Improvements in Carpet Making

Early in the 19th century a great improvement in producing carpets occurred when the Jacquard apparatus, used in weaving to regulate patterns, was applied to the hand manufacture of carpets. It was not until later, however, that floor coverings came into general use. In 1841 Erastus B. Bigelow, a medical student in Boston, harnessed an ingrain loom to steam power and so increased the output from 8 yards a day to 25 yards. He also patented a power loom for weaving Brussels and Wilton carpets, and another for weaving tapestry carpets. Since then, innumerable improvements have been made in carpet manufacture.

Of machine-made carpets, Chenille Axminsters are the richest and costliest. They belong to the tufted or velvet pile class, the most expensive having piles seven-eighths of an inch high. Most of them are made in plain effects, often with two or three tones; but ingenious machinery has been invented to insert differently colored chenille braid so as to produce the most elaborate designs. Florid and obtrusively colored designs are characteristic of a cheaper variety of Axminster, known as "spool" Axminster.

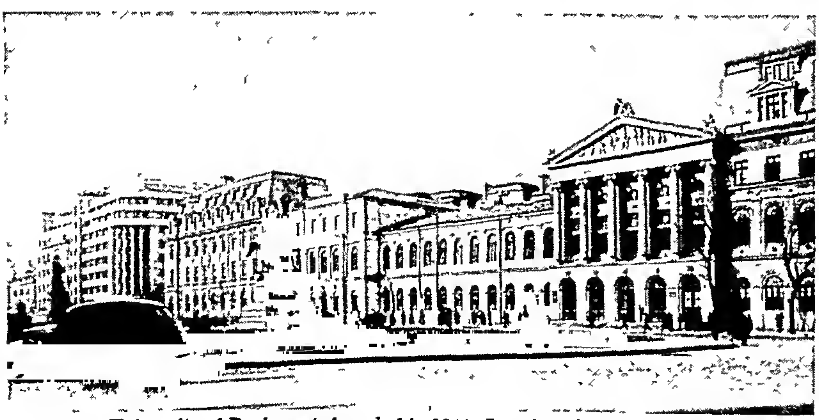
Rag Rugs and Grass Rugs

Rag rugs have been favorites in America since Colonial days, when every village had its weavers who made up into floor coverings the balls of rag strips sewed together by economical housewives.

Grass rugs, made of tough fibers, have become popular in recent years for special uses. Some have their colors woven into the mesh and some have the decorations stenciled on the finished material.

The United States today makes and uses more carpets than any other country in the world, the manufacturing centering in Pennsylvania, New York, and Massachusetts. In Philadelphia, where the first carpet factory was established in 1791, more carpets of all grades are made than in any other city in the world. They are sent to all parts of the earth.

A YOUNG NATION *and an* ANCIENT PEOPLE



This is the University of Bucharest, founded in 1864. Its educational system was modeled on that of France. Now it is directed by Communists.

RUMANIA (*ru-mā'nĭ-ȧ*). A typical Balkan nation in its turbulent history, its mixture of races, and the poverty of its peasant people, Rumania has natural advantages that set it apart from its more rugged neighbors to the south. Its petroleum fields are the largest in all Europe, and its farmlands are among the most important grain-growing regions.

Through nineteen centuries of history, it has been repeatedly overrun and conquered. Near the end of the second World War, Russia occupied the country. Rumania is now the Rumanian People's Republic under the firm control of Soviet Russia. Of all the countries behind the Iron Curtain, it is the most completely isolated.

The Land and Its Divisions

Rumania is the northernmost of the Balkan States. In the south it looks across the Danube River to Bulgaria and on the southeast it borders the Black Sea. Russia is its neighbor on the east and north, and Hungary and Yugoslavia on the west. Reduced by territorial revision in 1947, its area is now 91,671 square miles, smaller than Oregon. Population (1948 census), 15,872,624.

The Carpathian Mountains run down from the north and meet the Transylvanian Alps to form a triangular mountain mass in the heart of the country (for map, *see* Balkan Peninsula). These weathered ranges rise to heights of only 7,000 or 8,000 feet, and between them lies the hilly region called Transylvania. On the western side of the triangle stand the Bihar Mountains. The foothills slope down to plains that almost completely encircle the mountains.

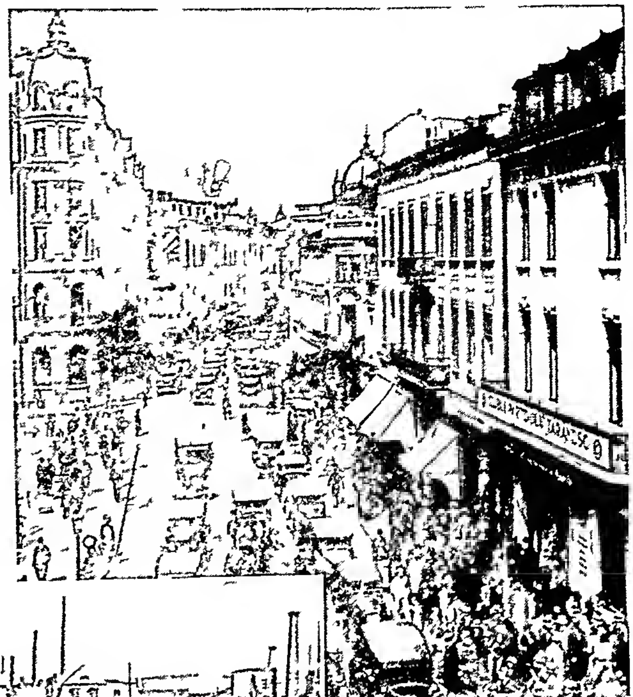
To the east between the Siret and the Prut rivers lies the plain and foothill region historically known

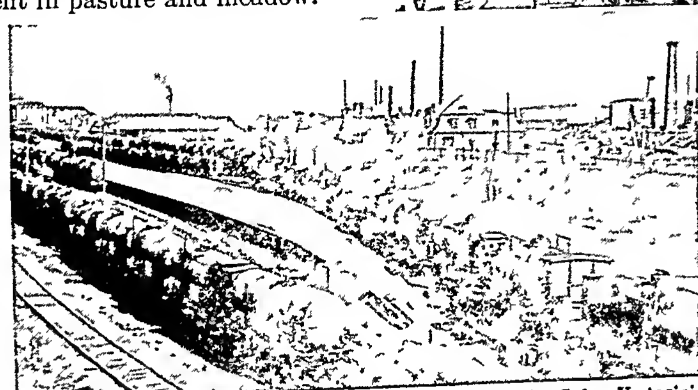
as Moldavia. The Danube plain to the south is called Walachia. The marshy Black Sea coastal plain is known as Dobruja. A lowland section on the west, south of the Maros River, is part of the Banat. This, like much of Transylvania, was once Hungarian territory. The chief cities are Bucharest, the capital, Cluj, and Timișoara (*see* Bucharest).

Products of Fertile Plains and Valleys

Rumania's plains are fertile, well-drained, and readily cultivated except for the marshy stretches along the lower Danube. The flat lowlands are given over almost wholly to growing grain, chiefly corn and wheat. The mountains and hills are interlaced with fertile, gently-sloping valleys where potatoes, sugar beets, tobacco, vegetables, and forage crops compete with grain in importance. Vineyards and orchards clothe the sunny slopes. Cattle and sheep graze throughout the plains and foothills. In all, about 43 per cent of the country is under cultivation, with an additional 13 per cent in pasture and meadow.

IN BUCHAREST AND PLOESTI





The top picture shows smart shops and cafés lining the Calea Victoriei, the main street of Bucharest. In the bottom picture we see long trains of tank cars pulling out of Ploesti, center of the country's rich oil fields. The Germans worked these fields during the second World War, and the area was heavily bombed by American fliers.

Hills and mountains are well wooded, and lumber has been a valuable export; but many forests are too far from transportation to be cut profitably.

The oil fields that supply Rumania's chief mineral wealth lie in the vicinity of Ploesti in Walachia. The adjacent natural gas has been little developed. Other minerals—including rock salt, coal, lignite, marble, iron, manganese, copper, gold, and silver—are found mainly in Transylvania. Some chemicals, metal products, and textiles are made from the output of Rumanian fields and mines, but in general manufacturing amounts to little. A small fishing industry is based upon the carp, sturgeon, salmon, and pike caught in the Danube.

The People and the Communist State

Most of the people get their living from the soil. The yield for each acre is low, and the government takes much of the produce. Both peasants and city workers live in terror of the security police. They are always removing "class enemies" to forced-labor camps.

Meager summer rainfall and frequent droughts get some of the blame for the small crops, though the climate in general resembles that of other grain belts, with cold winters and hot summers. Primitive methods of cultivation cut the potential yield severely. The land was formerly occupied by large estates where the peasants lived like medieval serfs. Agrarian reforms after 1921 carved up some of these estates and turned the fields over to the peasants. The Communist government divided up the remaining estates. But it soon began to socialize agriculture by combining small farms into large state-owned "collectives."

Capital is scarce in the country as a whole. Foreign firms led in the development of the petroleum fields and in building the pipe line that carries oil from the Ploesti region to Constanta (Kustenje) on the Black Sea. Inadequate railways and highways leave wide areas without transportation for crops, lumber, or minerals. Though the Danube makes a water highway between the Black Sea and central Europe and supports the two river ports of Galatz and Braila, it has numerous disadvantages. Strong currents near the "Iron Gate" make upstream travel difficult. Using forced labor the government began work in 1949 on a canal from the Danube to the Black Sea, north of Constanta.

Rumania's political instability in the past arose in part from conflicts between the various national and religious minorities. Rumanians make up some 70 per cent of the population, while other peoples include Germans, Hungarians, Bulgars, Ruthenians, Jews, Poles, Serbs, Turks, Czechs, and gipsies. Although the government has had a constitutional form since 1866, whatever faction happened to be in power usually governed in a dictatorial manner.

Conquered by Rome and Turkey

This region just north of the Danube, known as Dacia, was conquered by the emperor Trajan in A.D. 79 and ruled as a Roman province for nearly 200 years. The Rumanians claim descent from Roman soldiers and colonists, and regard their land as "an

outpost of Latin culture set in the East." In appearance and language the Rumanians resemble the Italians, though with much Slavic admixture. When the Roman legions withdrew, the land was in turn overrun by Goths, Huns, and Bulgars; and in the 6th century there came the great invasion of the Slavs.

The states of Walachia and Moldavia began to take form in the 13th century and were able to make a vigorous resistance when the Turks conquered the entire Balkan Peninsula in the 15th century. Later these states were pawns in the rivalry between Turkey and Russia. After the Crimean War, the Treaty of Paris (1856) recognized them as self-governing parts of the Ottoman Empire. By electing the same governing prince, Alexandru Ioan Cuza (Alexander John I), they managed to unite as a new nation called Rumania (native "Romania") with Bucharest as its capital. In 1866 they were given a German king, the Hohenzollern prince Charles, or Carol I; and in 1878 complete independence was finally achieved.

UNCHANGING PEASANT RUMANIA

Rural Rumania has changed little in a thousand years. The farmer raises what he needs; his wife spins and weaves his picturesque shirt and embroiders his jacket. These hardy peasants descended from the Romans.

Territorial Gains and Losses

In the second Balkan War (1913) Rumania aided Serbia, Greece, and Montenegro against Bulgaria, and was rewarded by additional territory in Dobruja. In the first World War Rumania sided with the Allies. As a result it was ravaged by a German-Austrian-Bulgarian army in 1916 and forced to sign a humiliating peace. But when the Central Powers were defeated, Rumania won its reward, receiving under the peace treaties the former Hungarian territory of Transylvania, the former Austrian district of Bucovina, and Bessarabia, east of the Prut River, which had been a part of czarist Russia. Rumania was thus more than doubled in size and population.

Queen Marie, an English princess, was the real ruler during much of the reign of her husband, King Ferdinand I, from 1914 to 1927. Her son, Prince Carol, abdicated in 1925 in favor of his young son Michael (Mihai); but he returned in 1930 and was crowned as Carol II. Rumania declined under his inept rule. A ruthless fascist group, the Iron Guard, seized control and aided Germany in gaining economic domination of Rumania. In 1939 Britain and France guaranteed Rumanian independence. But their pledges failed in 1940 when Germany won sweeping victories early in the second World War (*see* World War, Second).

Reluctant German Ally in Second World War

Left a satellite of Germany, Rumania was then forced by the Nazis to cede land to Russia, Bulgaria, and Hungary. Carol abdicated and was succeeded by his son Michael. In 1941 Germany virtually occupied Rumania and forced it into war on Russia. Rumania fought reluctantly, suffering huge losses.

When the Russians invaded in August 1944, Michael gained control of the government and surrendered (Aug. 23, 1944). Rumania was thus the first Axis nation to quit the war finally. It joined the Allies and actively fought the Germans. Michael remained king, but Rumanian Communists gained control.

In 1947 the peace treaty gave southern Dobruja to Bulgaria and Bessarabia and northern Bucovina to Russia. The treaty also returned Transylvania from Hungary.

Although Rumania had suffered far less damage than it had in the first World War, reconstruction was slow. The Communist-dominated government divided large estates, but the peasants lacked equipment to work as independent landowners. Severe droughts further cut grain production, and Russia seized livestock and machinery as reparations. To avert widespread famine, the United States shipped tons of food to the stricken country.

Under Communist pressure, Michael abdicated in 1947. Rumania became a "republic," controlled by Russia. In 1951 the Communist regime began a five-year plan to industrialize Rumania but accomplished so little that many leaders were purged in 1952. (For Reference-Outline and Bibliography, *see* Europe.)

RUMINANTS. Nearly all the mammals most useful to man—cattle, sheep, goats, camels, llamas, deer, and antelopes—have the habit of swallowing their food and later bringing it back to the mouth to be chewed thoroughly at leisure. Hence they are called the "cud-chewing" animals or ruminants. Their ancestors, being an easy prey to the stronger, fiercer, flesh-eating beasts, many thousands of years ago took to protecting themselves by swallowing their food hastily and retiring to more concealed places to chew at their leisure.

This is made possible by their complicated stomach with four compartments—the paunch or *rumen*, the *reticulum* or honeycomb bag, the *omasum* or manyplies, and the true stomach or *abomasum*. The food when first swallowed goes, in the form of a coarse pellet, into the paunch, the largest of the four compartments. There it is softened and passed into the reticulum, where it is molded into pellets or "cuds" of convenient size. Later, these are passed up into the mouth by *regurgitation*, a process the opposite of swallowing. After mastication they are swallowed again, passing into the third stomach or manyplies, then into

the fourth compartment or true stomach. The camels differ from other ruminants in having no third stomach.

Cattle, sheep, goats, and all the other ruminants except camels and llamas have no front teeth in the upper jaw. Instead the gums form a tough pad. In grazing, this pad holds the grass across the sharp edges of the lower front teeth. Then, with a sideways jerk of its head, the animal shears through the grass stems. The back teeth of ruminants are specially adapted for the kind of rotary grinding needed to shred and break up vegetable fibers.

RUSHES. All the grasslike plants of bogs and marshes are popularly spoken of as rushes or sedges. The true rushes, however, belong to a distinct family (*Juncaceae*), comprising more than 800 known species. They are closely related to the lilies, and all have tiny, greenish, lily-like flowers. The leafless and unbranched stems are usually hollow or filled with soft pith. The leaves are long, slender, and grasslike. Rushes are used now for basket-weaving, chair bottoms, ropes, etc.; but in medieval times in Europe they were strewn on floors and used as bedding. The pith of certain species was used for wicks in making "rush lights." Some species of both sedges and rushes are called bulrushes. The American bulrush is a sedge (*see* Sedge). "Horsetail" rushes are close relatives of the ferns. They contain much silica, or sand, and are used for scouring, and so are called "scouring rushes."

RUSKIN, JOHN (1819–1900). Do you know the charming fairy tale of 'The King of the Golden River', who helped the kind-hearted Gluck and turned the wicked brothers into black stones? John Ruskin, who wrote this story, was not unlike the kind Gluck himself. When his father left him a fortune of a million dollars he gave almost all of it away to art museums and charities. The story ends, "And Gluck went and dwelt in the valley, and the poor were never driven from his door; so that his barns became full of corn, and his house of treasure." Though Ruskin never got back his treasure, as Gluck did, he certainly never was in want, for his writings brought him in $20,000 a year.

JOHN RUSKIN
The Great English Art Critic

At first he wrote mostly about painting and architecture. His 'Modern Painters', 'The Seven Lamps of Architecture', and 'The Stones of Venice' gave the people of Queen Victoria's reign a new interest in art and a new point of view toward it. But when he was about 40 he began to be more interested in humanity and became a social reformer. His writings changed and began to describe what he thought would be an ideal state of society and how he thought this could be brought about. Ruskin knew comparatively little about sociology or economics. So he was now less successful, though 'Sesame and Lilies', a popular statement of some of his sociological ideas, became very well known. More impressive than the things Ruskin said was the *way* he said them. He wrote beautiful clear English, at times very simple and straightforward, and at times highly decorated and colored.

Ruskin was born and lived in England, but his parents were Scottish. His father was a wealthy wine merchant, and as John was their only son the parents devoted themselves almost entirely to his education. He went to Oxford, where he took a prize for poetry, and was graduated in 1842. In his later life he was professor of art at Oxford.

His autobiography, 'Praeterita', tells of his early life. His works amount to more than 50 volumes. Aside from those already mentioned the best known is probably 'The Crown of Wild Olive'.

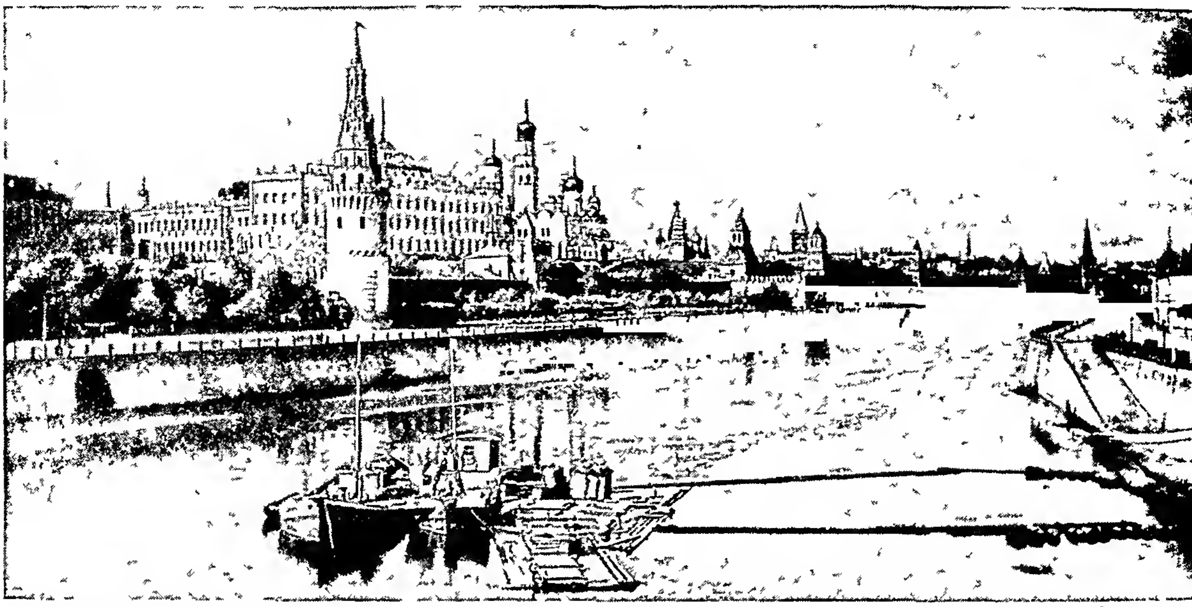
RUSSELL, JOHN (1792–1878). In a great mass of journals and memoirs, the English statesman and Whig leader Lord John Russell recorded his long and eventful life. He tells of his boyhood in London, where he was born, of his school days at the University of Edinburgh, of his travels on the Continent, and of his entry into Parliament at the age of 21.

The most exciting part of the story occurred in 1832—the year of the great Reform Bill. The Tory Duke of Wellington had been forced to resign as prime minister, because he was opposed to the reform of Parliament. The Whigs (Liberals) then came into power with Earl Grey as prime minister. Lord John Russell was given the task of championing the measure which did away with the "rotten boroughs" (where few or no people lived) and gave representatives to the new manufacturing cities, which had not been represented in Parliament. The House of Lords rejected it. Elections were held, and excited mobs demanded "the bill, the whole bill, and nothing but the bill." Finally the Lords were forced to yield because of the threat that enough Whig peers would be created to give the necessary majority in their house.

The rest of the story was less eventful. His share in the great political and humanitarian reforms that followed was unimportant. No great laws were passed in Russell's first term as prime minister (1846–52), and his second term (November 1865—June 1866) was too short to allow him to accomplish anything.

By this time he had lost much of his popularity in the country. His sympathy with the South during the American Civil War led the friends of America to believe that he had purposely allowed the Confederate cruiser *Alabama* to escape in 1862 (*see* 'Alabama' Claims). The mismanagement which marked England's entrance into the Crimean War (1854–56) was blamed on him. When he retired in 1866, at the age of 74, Gladstone took his place as leader of the Liberal party.

Vast RUSSIA—*Its* LAND *and* PEOPLE



This huge group of buildings is the Kremlin (fortress) of Moscow. For centuries it was a palace of Russia's rulers, the czars. Today it shelters the supreme government. From it Russia's Communist rulers control the lives and work of the people. They also conduct Russia's relations with all other nations. It is one of the most important political centers in the world.

RUSSIA. The largest country in the world is Russia. It stretches across both Europe and Asia, 6,500 miles from the Baltic Sea to the Pacific Ocean. Russia is three times as large as the United States without Alaska and island possessions. Russia is the home of 201,300,000 people (1950 est.). The country has enormous resources in farmland, forests, and minerals.

> **DIFFERENT NAMES FOR RUSSIA**
>
> For many centuries, English-speaking peoples called the land of the czars "Russia." This name is still appropriate when discussing the land, its culture, and its long history. In 1917 a revolution established a Communist government, and in 1924 the country received its present official name, the "Union of Soviet Socialist Republics" (abbreviated as U.S.S.R. or Soviet Union). English-speaking people often combine the word "Soviet" (from the official name) with the historic name "Russia." Thus the terms "U.S.S.R." and "Soviet Russia" mean the Russia of today.

The way of life in this giant land differs greatly from that in a democracy. Russia is ruled by a dictator who wields absolute power; and its economic system is based on Communism. The government owns the land, the factories, and all other property. All Russians must work and live as the dictator orders. Russia established this form of government after a revolution against its czar in 1917. The people hoped that Communism would relieve the poverty and cruelty suffered under the old rule.

Extent.—East to west, greatest distance, about 6,500 miles; north to south, about 2,400 miles. Area, about 8,570,600 square miles; area in Europe, about 2,110,600 square miles. Total population (1950 est.), 201,300,000. Composed of the following Soviet Socialist Republics: "Russia Proper," Karelo-Finnish, Estonian, Latvian, Lithuanian, White Russian, Ukrainian, Moldavian, Georgian, Azerbaidzhan, Armenian, Kazak, Turkmen, Uzbek, Tadzhik, Kirghiz.
Natural Features.—Ural, Caucasus, Tien Shan, and Altai mountains; Pamir Plateau Rivers: Volga, Dnieper, Don, Dvina, Dniester, Ob, Yenisei, Lena, Amu Darya, Syr Darya. Lakes: Ladoga, Onega, Ilmen, Balkhash, Baikal, Aral; and Caspian Sea.
Products.—Wheat, sugar beets, oats, rye, barley, millet, corn, potatoes, sunflowers, tea, cotton, flax, hemp, rami, rubber plants; timber; cattle, sheep, goats, swine, horses; coal, peat, petroleum; iron, manganese, copper, zinc, lead, bauxite, nickel, gold, platinum, apatite, potassium salts, asbestos; sugar, flour; meats, butter; furs, hides; textiles; tractors, agricultural machinery, machine tools; wood pulp and paper; fish and caviar; petroleum products, chemicals, rubber products, fertilizers, cement, glass, matches.
Cities.—Moscow (capital, 4,500,000); Leningrad (3,300,000); Kiev, Kharkov, Gorki, Baku, Odessa, Kuybyshev, Tbilisi, Rostov, Dnepropetrovsk, Stalino, Saratov, Kazan (all between 900,000 and 500,000). (For population of Siberian cities, see Siberia.)

The revolutionary leaders established Communism firmly in Russia. They also worked to establish Communism throughout the world, as explained in the article on Communism. Because the Russians aim to impose Communism on everyone, people everywhere should learn about Russia, and Communism as a way of life.

A Seventh of All the World's Land

RUSSIA is large not only when compared with other countries; it is huge even when measured against the entire world. It covers one seventh of all the land on the earth. Its total area (about 8,570,600 square miles) is larger than South America and almost as large as North America. European Russia (2,110,600 square miles) is larger than all the rest of Europe.

This huge area is not so rich as it is large. Much of it lies north of the Arctic Circle, on a line with northern Alaska and southern Greenland. The bleak tundra land will not support forest or farms.

In Europe the southernmost parts lie in line with the United States from northern Maine to Virginia in the east, or from Seattle to San Francisco in the west. East of the Black Sea, a large area is covered by the snow-clad Caucasus Mountains, the

highest in Europe. In Asia, the southern limits are much the same; but immense portions of the southern region are too dry for farming or are deserts. Despite the waste areas, however, Russia still has enough land to support a huge population.

The Vast Plains of Russia

Most of the land is a vast plain. In Europe, flat land stretches from the Arctic Ocean and its arm, the White Sea, on the north to the Black Sea and the Caucasus Mountains on the south. The highest part is the Valdai Hills, east of Lake Ilmen; but they rise only from 600 to 1,200 feet above sea level.

About 1,400 miles east of the Polish border, the Ural Mountains lift gentle, wooded crests a few thousand feet above sea level (*see* Ural Mountains). They extend about 1,600 miles north and south. The people and power of Russia developed west of this range. Therefore the division between Europe and Asia is placed at the Urals.

East of the Urals lies Siberia in Asia. Here the land rises gradually from sea level at the Arctic Ocean to an elevation of several thousand feet at the foothills of mountain ranges in the south and southeast.

Mountains Rim the Vast Plain

Aside from the Urals, all the important mountain ranges in Russia lie in a huge arc along its southern and southeastern borders. Beginning at the west, the first important range is the Caucasus, between the Black and Caspian seas. Here is Mount Elbrus, the highest peak in Europe (18,481 feet). In prehistoric and ancient times, this range protected the civilized peoples of Asia Minor from the nomads who lived on the Russian plains. During the 19th century, Russia conquered territory south of the main ranges. The present frontier is the dividing line between Europe and Asia in this region.

East of the Caspian, Russia extends southward to the edge of the mountainous plateaus occupied by Iran (Persia) and Afghanistan. Then a bulge along the border with India rises to "the roof of the world," the lofty Pamir Plateau. Here stands the highest of all Russian peaks, Mount Stalin (24,590 feet). North and northeast of the Pamir, along the border with China, are the lofty, snow-clad Tien Shan and the Altai Mountains. Lower ranges are scattered over eastern Siberia. The Stanovoi Mountains run in sweeping curves to Bering Strait, the division between Asia and North America.

Mighty Rivers and Large Lakes

Most of the river drainage in European Russia flows north or south from a low divide that lies between the Valdai Hills in the west and the Ural Mountains in the east. The two greatest northern rivers are the Duna, flowing to the Gulf of Riga, and the Dvina, draining to the Arctic Ocean. (Soviet Russia calls these rivers the Dvina, or western Dvina, and the northern Dvina.) Between them several lakes (Peipus, Ladoga, and Onega) empty into the Gulf of Finland.

The southern slope of the divide and the western Urals drain through the Volga River, the longest in Europe, into the landlocked Caspian Sea. The region south of Moscow is drained into the Sea of Azov by the Don and its tributary, the Donets. In the southwest the Dnieper, Bug, Dniester (or Dnestr), and Prut flow from the vast Pripet Marshes southwest of the Valdai Hills, or from the Carpathian Mountains, to the Black Sea. Most of the rivers flood when the snow and ice melt in the spring.

Four great rivers of Siberia rise in the snow-capped mountains on the southern border. The Ob (with its long tributary, the Irtish), the Yenisei, and the Lena flow north to the Arctic Ocean. The Amur enters the Pacific Ocean. Lake Baikal, in the mountains of eastern Siberia, is almost twice as large as Lake Ontario (*see* Baikal, Lake).

In southwestern Asia the Syr Darya River rises in the Tien Shan Range and the Amu Darya on the Pamir Plateau. These twin rivers plunge down mountain gorges, irrigate broad valleys, and then flow northwest, pushing their diminished waters through desert sands to salty Lake Aral (*see* Aral, Lake). At the foot of the Tien Shan lies the broad crescent of Lake Balkhash, about two-thirds the size of Lake Erie.

ON THE RUSSIAN GRASSLANDS

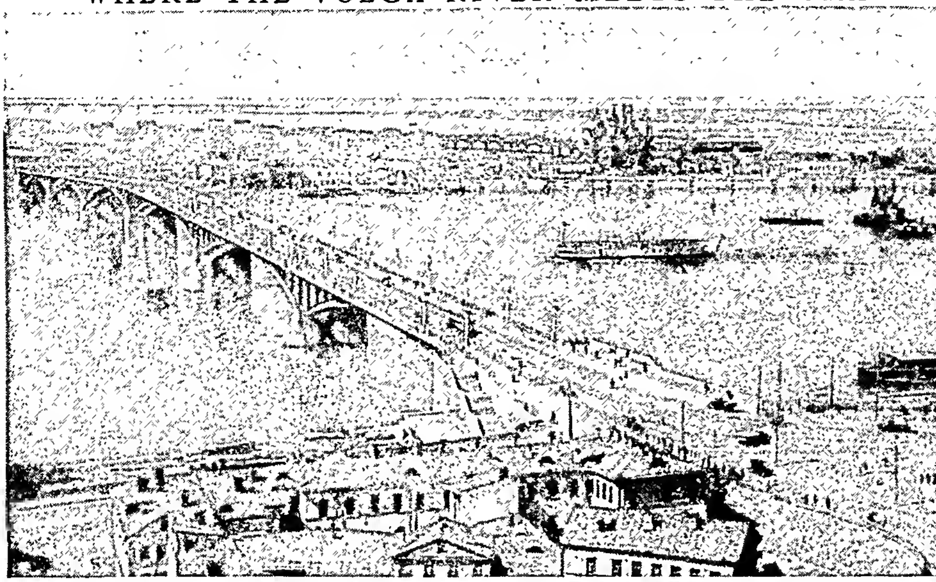
At the left is a prehistoric monument standing on the Siberian steppe. The stone came from the near-by Altai Mountains. Through the ages, dust-laden winds have worn it nearly smooth. At the right, a Don River Cossack lassoes a horse on the grassland near the Black Sea

Climate Zones in Russia

Over the whole vast Russian plain in Europe and Asia, both natural and human life are adapted to changes in temperature from north to south and changes in precipitation (rain and snow) from west to east.

One-fifth of Russia lies in the frozen north and only a small fraction in the subtropics. The rest is in the

WHERE THE VOLGA RIVER MEETS THE OKA



At Gorki the Volga River, winding eastward, picks up its first great tributary. This Moscow-bound steamer has just left the Volga (in the background) and is nearing the Oka bridge.

In the Arctic north the land is a bleak, treeless tundra. The nine-month winter freezes the ground deeply. Frogs hibernate by freezing solid. If dropped on a hard surface, they break into bits. In summer the surface layer thaws, and the plain becomes a vast swamp, covered with lichens, mosses, and berries. Shaggy polar bears live along the shore, and ermine and polar foxes farther inland.

Forests, Steppes, and Deserts

Farther south a cold evergreen forest (conifer trees) blankets almost half of European Russia and nearly all Siberia. Brown bears, wild boars, wolves, and lynxes live in the trackless woods. The soil is a thin type called *podsol* (*see* Soil).

South of the evergreen forest, plant life and soil vary with changes in precipitation. Except over central and eastern Siberia, the moisture-bearing winds come from oceans to the west. Precipitation is about 20 inches a year in the west. It falls off steadily as the winds blow eastward.

In central European Russia, longer summers and ample moisture produce broad-leaved trees among the conifers. Most of this mixed forest zone has been plowed up for farmland. Farther east and south the leafy trees disappear except along the river banks. Instead, a rolling, grassy prairie (called *steppe* in Russia) spreads like a calm sea for thousands of miles.

The better-watered portions of the steppe produce tall feather grass. Shorter grass comes in as rain-

temperate or middle zone. This great inland area has a continental climate with extreme differences between winter and summer (*see* Climate). The northern half of Europe and Russia has winter temperatures as low as −40° F. In much of the southern half the thermometer may drop below −20°. Summers are hot everywhere. Even at Archangel on the Arctic Ocean, the temperature may reach 86°. At Verkhoyansk in eastern Siberia, the "cold pole" of the earth, a winter temperature of −94° has been recorded and a high of 91° in the brief summer.

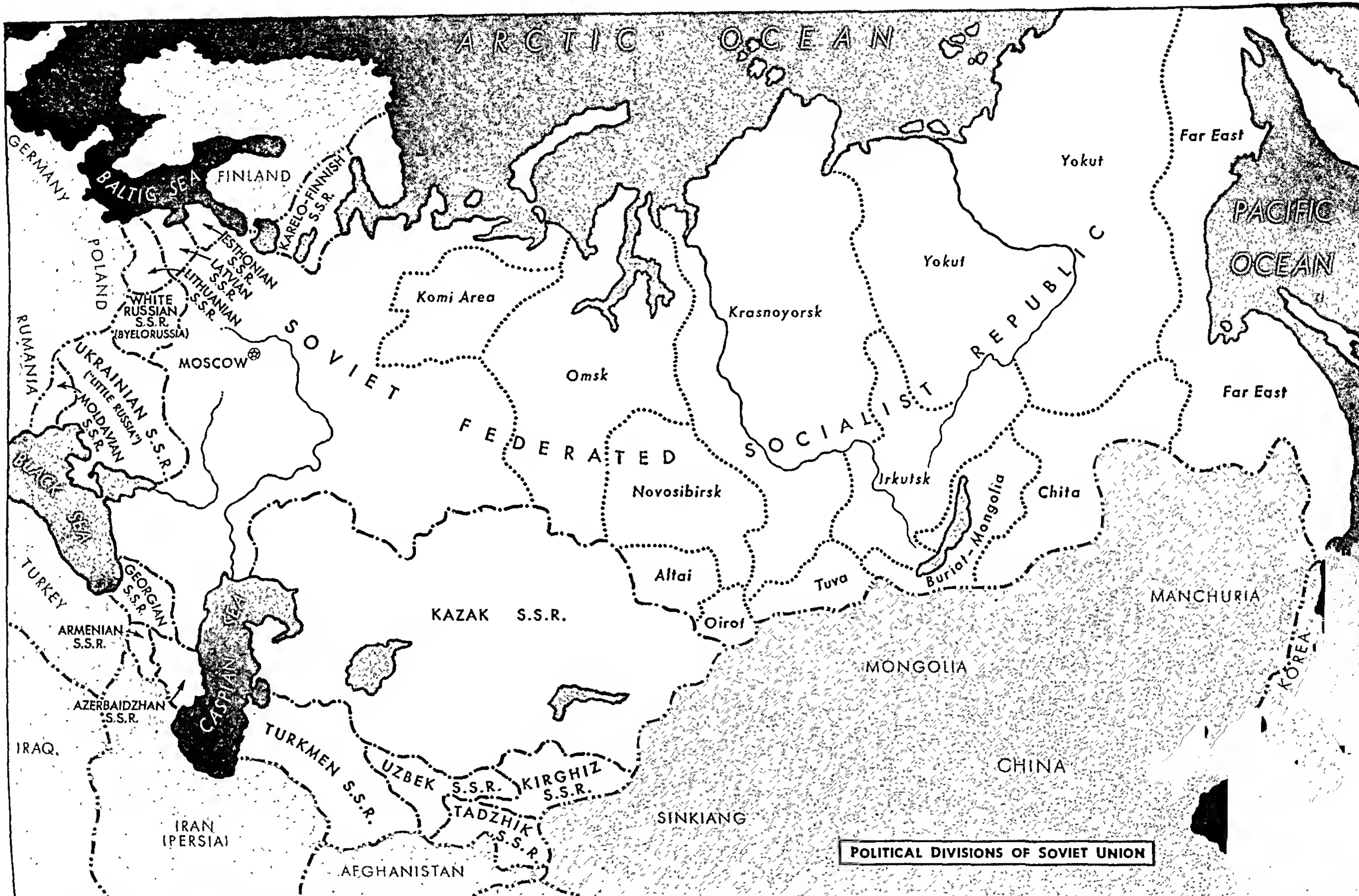
Masses of Arctic air often blow far south. In winter they bring the dreaded *buran*, a violent blizzard. In summer they become warmer and absorb moisture as they blow southward. Often they cause dust storms. If they blow too frequently, they bring drought.

The frost-free growing season varies from a few weeks in the north to many months in the south. Both plant life and soil match the variations in climate.

SCENES FROM SOUTHERN RUSSIA

At the left, we see a health resort, Livadia, on the warm Crimean shore. Once it was an estate of Czar Nicholas II. Now it provides vacations for Soviet officials and favored workers. At the right, is one of the twin cones of Mount Elbrus, an extinct volcano in the Caucasus. This view of the lower crater was taken from a hotel on the higher peak (18,481 feet), the highest mountain in Europe.

The largest country in the world, Russia is an enormous, flat plain which stretches across all eastern Europe and northern Asia. Except for the Urals, which separate Europe from Siberia, the only mountains are around the fringes. Its rivers include the Volga, longest in Europe, and the even longer Ob, Lena, and Yenisei of Siberia.



Like chicks around a mother hen, the smaller republics cluster around the giant Soviet Federated Socialist Republic. Dots and dashes (---) indicate the boundaries of these sixteen self-governing Union republics. The dotted lines (. . .) mark off the larger administrative areas within the vast S.F.S.R Some of these also have a measure of self-rule.

fall becomes less. Today in European Russia most of the steppe land is plowed, and its black earth supports a rich wheat belt. This soil (called *chernozem*) is not leached by the light rainfall and is six feet deep in places.

Farther east the green grasslands change to semiarid plains. Beyond the Caspian Sea stretch the sandy deserts of Kara-Kum and Kizil-Kum. Snakes and tortoises abound here and lizards four feet long. A clay desert called *Bet-pak-dala* (the "Famine Steppe") covers the plateau between the Syr Darya River and Lake Balkhash. Below the mountains in Turkestan are irrigated tracts with green fields and flowering gardens.

Russia's Scarcity of Good Ports

Russia has about 27,000 miles of seacoast, but only a few good ports. The Arctic Ocean bordering the long northern coast is almost always frozen. The end of the warm Gulf Stream keeps Petsamo and Murmansk in the west ice-free the year round; but Archangel on the White Sea is icebound from November to May. Soviet Russia uses icebreaker steamers to serve Siberian ports in the summer. On the Pacific coast of Siberia also, the ports are icebound for months.

Leningrad on the Gulf of Finland, an arm of the Baltic Sea, is icebound from November to April. Repossession of Estonia, Latvia, and Lithuania during the second World War gave Russia ice-free ports on the Baltic. But traffic must pass through the narrow strait between Denmark and Sweden. Good ports exist on the Black Sea; but to reach the Mediterranean, vessels must pass through the Bosporus and the Dardanelles, two narrow straits held by Turkey.

A Patchwork of Nations

"RUSSIA is not a country," says a peasant proverb, "it is a world." More than 150 different peoples live in the Soviet Union. The central government controls them through 16 subordinate governments called republics. One huge republic governs most of the land occupied by Russians. The others govern adjoining smaller areas. Most of these republics contain divisions called autonomous republics, autonomous regions, or national areas.

"Russia Proper," the Giant S.F.S. Republic

The largest republic of the U. S. S. R. is the Russian Soviet Federated Socialist Republic, popularly called "Russia Proper" or the "S. F. S." It includes Great Russia in Europe and most of Asiatic Russia—four-fifths of the entire area of the Soviet Union. The S. F. S. adjoins other countries in the far east; on the west and south the smaller Union republics hem it in. Its capital, Moscow, is the capital of the Soviet Union.

The Fifteen Smaller Republics

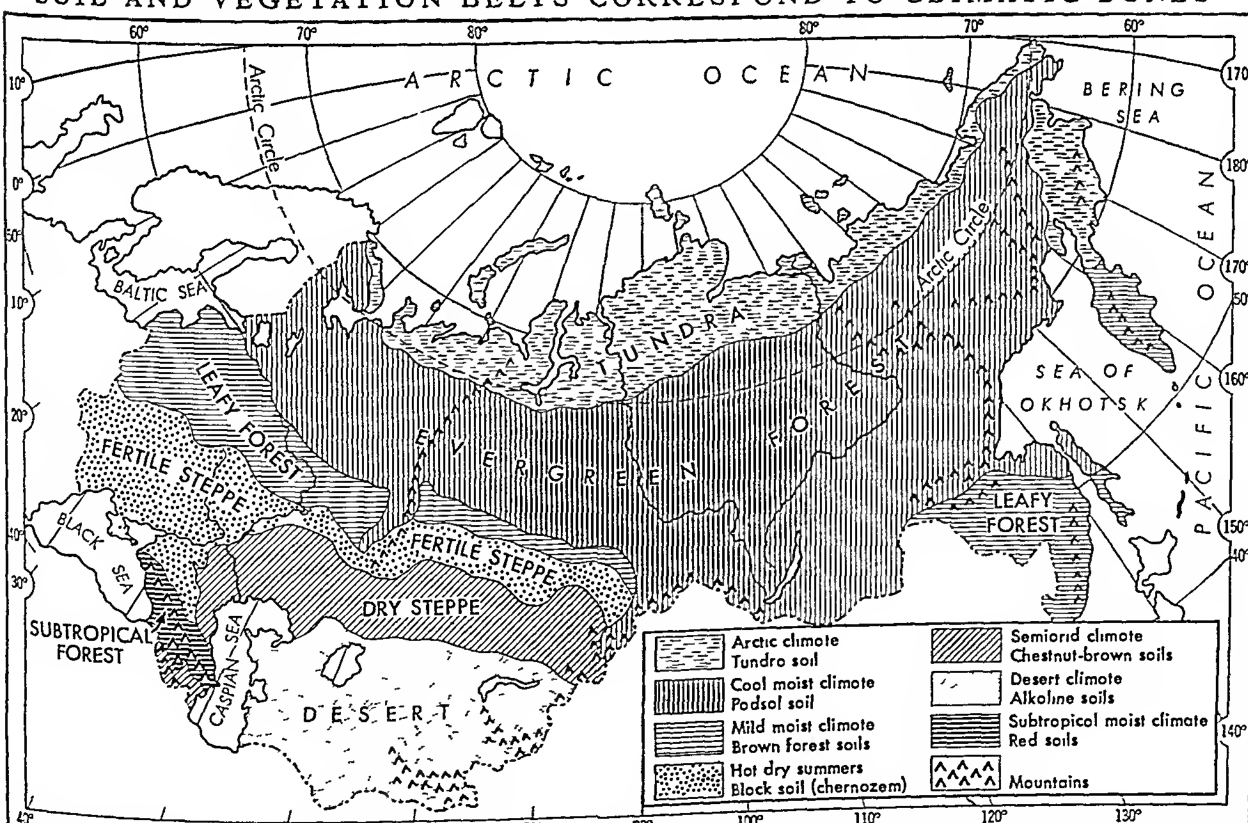
Beginning in the extreme northwest, and circling counterclockwise around "Russia Proper," the smaller republics are:

KARELO-FINNISH S. S. R., in extreme northwest, borders on Finland.

ESTONIAN S. S. R., southwest of Leningrad, on the Gulf of Finland.

LATVIAN S. S. R., south of Estonian S. S. R., on the Baltic Sea; chief city, Riga.

SOIL AND VEGETATION BELTS CORRESPOND TO CLIMATIC ZONES



In the northern tundra region, the climate is too cold for trees. Just south of the tundra, evergreen (conifer) forests can grow across Russia. Beneath them is "cool-forest" soil called podsol. South of the cool forest, plant growth and soil are determined by the regular decrease in rainfall from west to east. The main types are indicated on the map.

Lithuanian S. S. R., south of Latvian S. S. R.; borders on Poland in the west.

White Russian S. S. R. (Byelorussia), southeast of Lithuanian S. S. R.; borders on Poland.

Ukrainian S. S. R. (Little Russia), a large republic south of White Russia. In the west it borders on Poland and the Moldavian S. S. R.; in the south, on the Black Sea. Chief cities: Kiev (capital), Kharkov, and Odessa.

Moldavian S. S. R., between the Ukrainian S. S. R. and Rumania.

Georgian S. S. R., on southeast shore of the Black Sea; chief city is Tiflis.

Azerbaidzhan S. S. R., between Georgian S. S. R. and the Caspian Sea; chief city, Baku.

Armenian S. S. R., south of Georgian S. S. R. and Azerbaidzhan S. S. R.; borders on Turkey and Iran.

Kazak S. S. R., a huge republic between the Caspian Sea and Sinkiang (China); chief city, Alma-Ata.

Turkmen S. S. R., south of Kazak S. S. R., stretches east from the Caspian Sea; borders on Iran and Afghanistan.

Uzbek S. S. R., east of Turkmen S. S. R., chief city, Tashkent.

Tadzhik S. S. R., east of Uzbek S. S. R.; borders on Afghanistan in the south and Sinkiang (China) in the east.

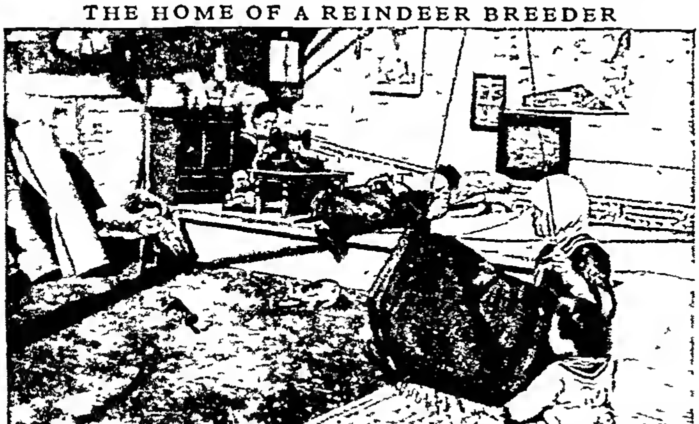
Kirghiz S. S. R., north of Tadzhik S. S. R.; borders on Sinkiang (China) in the east.

The Asiatic Peoples of the Soviet Union

Taking the Soviet Union as a whole, about 80 per cent of the people are white, 10 per cent yellow, and the remaining 10 per cent a mixture of the two. Compact groups of Asiatics, many with a rich and ancient culture, people the republics to the south. Smaller groups are scattered through the far north, the deserts, and the mountains. Some tribes live as primitively as North American Indians of colonial days.

Many Asiatics are Mohammedans. The most numerous are the Uzbeks, a Turkic people with black hair and slant eyes. The Uzbek men wear embroidered caps or white turbans. For centuries the Uzbek women have woven the famous Bokhara rugs in the shadow of beautiful mosques while the men tilled irrigated fields at the foot of the mountains (*see* Turkestan).

THE HOME OF A REINDEER BREEDER



These people live on the Tanguska River in northern Siberia. They fish and herd reindeer for a living. But some modern ways have reached them. Notice the sewing machine and the Soviet propaganda posters on the wall.

On the steppe-desert to the north of the Uzbeks live the Kazaks, nomad herdsmen, in their black felt tents. The typical Kazak shows his Mongolian ancestry in his black oblique eyes, broad flat nose, and high cheekbones. From earliest infancy his children learn to ride swiftly on their small shaggy horses. The name Kazak means "rider."

Farther west, in the valley of the Volga River, live the Tatars, who are also Mohammedans. They are among the most cultured of the descendants of the Golden Horde that flooded the Russian steppes in the 13th century (*see* Mongols; Tatars).

In the Caucasus the typical mountaineers are warlike Mohammedans with black eyes, aquiline noses, and well-chiseled Asiatic features. They wear daggers stuck in their belts, wide cloaks of natural black sheep wool, and great fur caps—even in summer.

In the southern Caucasus on the Black Sea live the Georgians, a white people who have long been famous for their blood feuds and their beauty. The typical Georgian has brown eyes and hair, a clear skin, and a tall graceful figure. Farther inland are the Armenians, a people with black hair and eyes and swarthy complexions. Both Georgians and Armenians have been Christians since the beginning of the Christian Era. The Azerbaidzhans, who are related to the Turks and Persians, are Mohammedans. (*See* Georgia; Armenia; Caucasus Mountains.)

Near the borders of Mongolia live the Buriats, nearly pure Mongols and worshipers of Buddha. The Yakuts, a Turkic tribe, raise cattle in the Lena River basin in northern Siberia, and the Ostiaks breed reindeer along the cold Ob River. On the shores of the Arctic in Siberia live Samoyeds and Eskimos. In Soviet Europe Lapps and Finns people the forests and marshes of the far north. (*See* Siberia; Lapland.)

The Russians, Conquerors and Pioneers

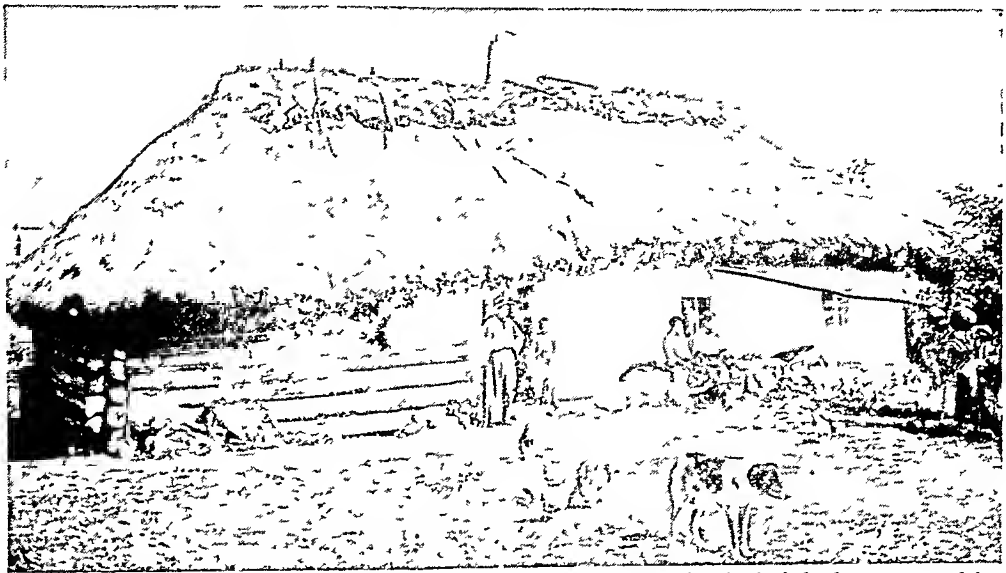
The overwhelming majority of the white people are Slavs. They also belong to various groups. At the top of the list stand the Great Russians, who number a hundred million people—more than half the population of the Soviet Union. They were the conquerors and pioneers, who for 500 years pushed out their frontiers at a prodigious rate, particularly eastward across Siberia. They have continued to expand wherever they could by settlement on new land or by conquest.

The Great Russians are a mixed race. Scandinavian, Finnish, and Tatar as well as Slavic blood flows in their veins. They have fair skins and many are blond, but the majority have dark hair. Closely related to them are the darker-skinned Ukrainians (Little Russians), who number 40 million (*see* Ukraine). Of purest Slavic blood are the White Russians, whose lands adjoin those of the Poles in the west, and the Cossacks. The Cossacks are descended from the adventurous freebooters who formerly roamed the "wild fields" along the Black Sea coast. These swift horsemen took their name from the hard-riding Turkish Kazaks (in Russian, "Cossacks"). From the Cossacks the czars recruited their ruthless cavalry (*see* Cossacks).

The typical Slavs have wide faces and high cheekbones. In general they are not large. The average

Russian soldier in the second World War was 5 ft. 6 in. tall and weighed about 160 pounds. But they are a tough and wiry people, capable in adversity of long-suffering patience and in war of almost superhuman courage and endurance. It has been said, "You could make nails of them, and never would nails be stronger."

THE SIMPLE CABIN OF THE RUSSIAN FARMER



The stuccoed, whitewashed walls enclose the living quarters. The other half of the house is used for storage. Whether he lives in wooded country or on the steppes, the farmer roofs his house with thatch.

Traits of Russian character help greatly to explain the Revolution of 1917 and the rise of Communism. As individuals, Russians are likely to be good natured, humorous, and fond of talking, singing, and dancing. When they are allowed to act as they like, they are unfailingly hospitable to strangers. But long centuries of tyrannical oppression and poverty under the czars left their mark. They came to believe that misery and oppression were natural and could not be helped. Their literature before the Revolution shows strong mysticism and fatalism, and pity for the weak and the poor.

When the Revolution came, the Russians supported it wholeheartedly. Anything would be better, they thought, than the old rule. The new Communist government was as drastic in its rule as that of the czars, but the Russians did not object. They had never known the rights of free citizens or of self-rule. It seemed natural to obey the orders of their new masters and hope that they would benefit in the end.

The results show clearly in the record of the two classes that were expected to benefit most from the Revolution and Communism. One class was the vast army of peasants on the farms. The other consisted of city factory workers.

Peasants of Old and New Russia

To understand the modern peasant of Soviet Russia, it helps to know his ancestors, the *muzhiks* of czarist days. They were bearded and tousle-headed, with mud on their boots; and they wore long linen blouses outside their trousers. Steeped in poverty, ignorance, and filth, the *muzhik* used to say, "We are a dark people." Then he would shrug his shoulders and mutter, *Nichevo!* ("What of it!").

During the long winters he spent 16 hours in bed. The rest of the time he hugged his stove, drinking tea and talking. "Work isn't a bear," he would say. "It won't run away to the forest." When spring came he labored mightily with his wooden plow, and scattered the seed as soon as the priest had blessed the land. In harvest time—the "suffering season"—the whole family went into the fields before dawn and toiled with scythes and sickles until dark. Their land consisted of tiny holdings which might lie in 50 different places. Each acre yielded little; but in good years Russia could export a surplus of a hundred million bushels of wheat.

Old Peasant Religion and Folklore

The *muzhik* could not read or write; but he had a rich spiritual life. He loved the mysticism and colorful ritual of the Russian Orthodox Church and its beautiful music. In the church he lit candles before his favorite icons—pictures of sacred figures painted on wood panels. Small icons in his hut showed episodes from the Holy Scriptures and the lives of the saints. They formed "the Bible of the poor." He celebrated the church feast days and observed its long fasts. Sometimes he went on pilgrimages to distant monasteries or even to the Holy Land.

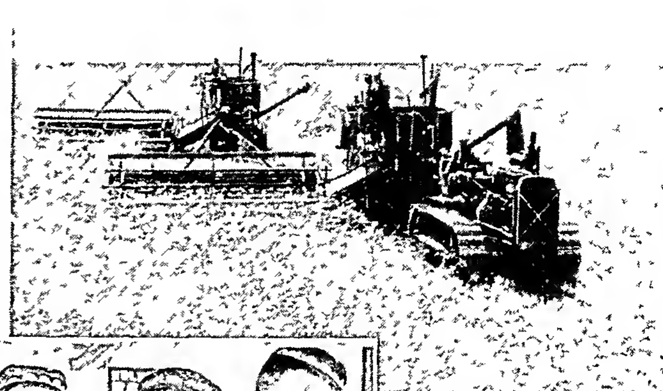
The more humdrum affairs of his daily life he entrusted to the spells and incantations of the witches and sorcerers who infested the villages. He thought they alone could control the fairies, the ghouls in the graveyard, the household sprites and wood sprites, and the spirits of local rivers and wells (*rusalkas*). All these beliefs and fears made up a rich folklore that was told from generation to generation.

Other legendary tales, chanted by wandering beggars, glorified the exploits of princes and heroes of old. Animals too had a place in songs and stories. Mishka the bear, the golden cock, and the humpbacked horse were favorites of all Russian children. But best of all they came to love the cat, which figures in hundreds of songs and stories. A Russian child says, "Sing me a cat, Mother," when he wants a lullaby. Russians in general do not care for dogs.

Home Lives of the Peasants

In spite of the Revolution the peasant's house has changed little since prerevolutionary days. Usually it has only one room. The floor is hard earth and the

WORK ON THE HUGE COLLECTIVE FARMS



At the top, tractor-drawn combines cut wheat on a field in the steppes. At the bottom, an Uzbek girl makes entries in her accounts for farmers on a collective farm.

roof is thatch. In the wooded north the walls are built of logs. On the steppes wood is scarce, and the walls are made of mud brick, whitewashed inside and out. In the main room stands a great brick oven, which sometimes reaches from wall to wall. This is used for both cooking and heating. In bitter winter weather the family seals the windows and everybody sleeps on top of the stove. A covered hole in the floor serves as an icebox.

The peasant's food is coarse and simple. His daily diet usually includes *kasha*, a cereal prepared from millet grits; beet soup (*borsch*), sometimes with sour cream in it, or cabbage soup; potatoes and heavy rye bread, called "black bread." In summer, he adds cucumbers and other fresh vegetables to his meals. The peasant chews dried sunflower seeds as Americans chew gum.

Each village has its bathhouse, a small snug shack with benches along the walls. The peasants drop hot stones into barrels of water and enjoy steam baths which last for hours. Now and again they rush out-of-doors to rub one another briskly with snow. Then they return to the bathhouse and drink huge quantities of tea.

The Revolution and Communism

Before Communism came to Russia the peasant had already had lessons in cooperation and collectivism. Aside from the huge estates belonging to the state, the nobility, and other wealthy landlords, the land was owned by the entire village community, called the *mir* (land commune). Under this socialistic arrangement pasture, farmland, and woods were divided periodically among the members according to the *mir* code. All cooperated in planting and harvesting and used the same threshing floor and mill. Russians commonly said, "It has been done by the whole *mir*." Village handicrafts also were carried on under a coöperative system known as the *artel*. But in spite of all the coöperation, every peasant felt the farmer's deep desire to own land.

When the Revolution came in 1917, the peasants believed that it would meet their deepest desires. They thought that the great estates of the nobles would be broken up and all the peasant workers would get farms of their own. So they formed councils (called *soviets* in Russian) and helped eagerly to extinguish the nobility and wealthier townspeople by killing them or forcing them to flee.

They soon learned, however, that the Communist leaders had other plans. The leaders wanted to use modern agricultural machinery, and to do so profitably they had to have large fields. So they asserted the Communist doctrine that the state owns all the land, and organized large *collective* farms

The state pushed through its plan ruthlessly. Old owners, rich or poor, were dispossessed. Dislocations combined with unfavorable weather produced widespread famines in 1921–22 and 1932–33. Millions died, but the state did not turn from its plan. Thousands of little settlements disappeared from the map as the villages merged their holdings into large collectives. Young people by the millions were drawn away to work in mines and factories. Wealthier peasants (*kulaks*) were driven from the land or executed as enemies of the state The other peasants lost what little freedom they had gained. Now they were working for the all-powerful state. They could no longer decide what to raise or when to plow. The state decided everything. It took a huge allotment of the harvest. Peasant workers got shares from the remainder.

Today's Peasant Homes and Collectives

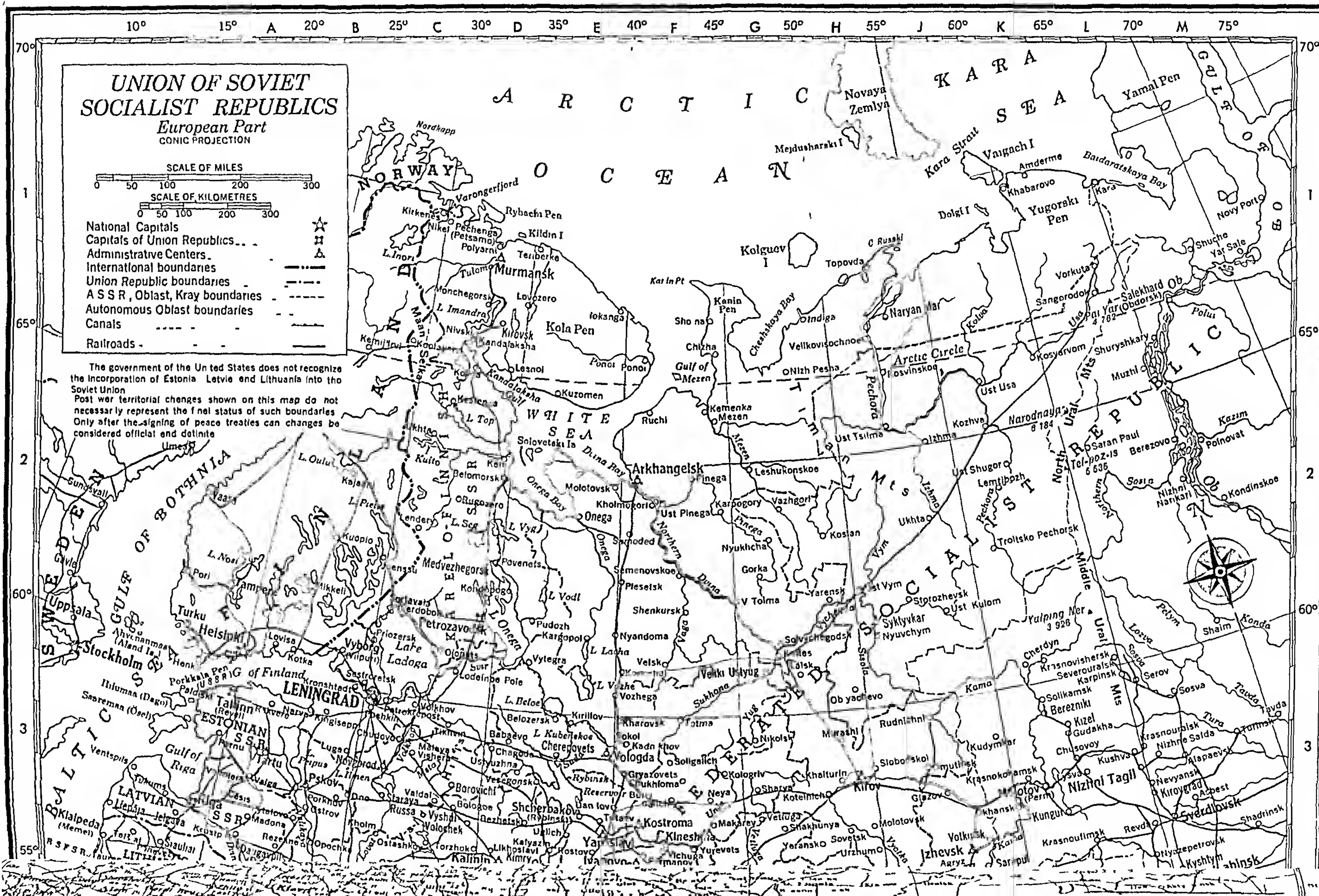
The peasant can have his own hut, a cow, and a few pigs and chickens. He can also garden an acre or two. If he can spare any produce from his own plot, he sells it at a town market. He and his wife have little time to garden after doing their prescribed "work units" on the collective. Yet the peasants work their gardens intensively enough to provide a fourth of Russia's total agricultural production.

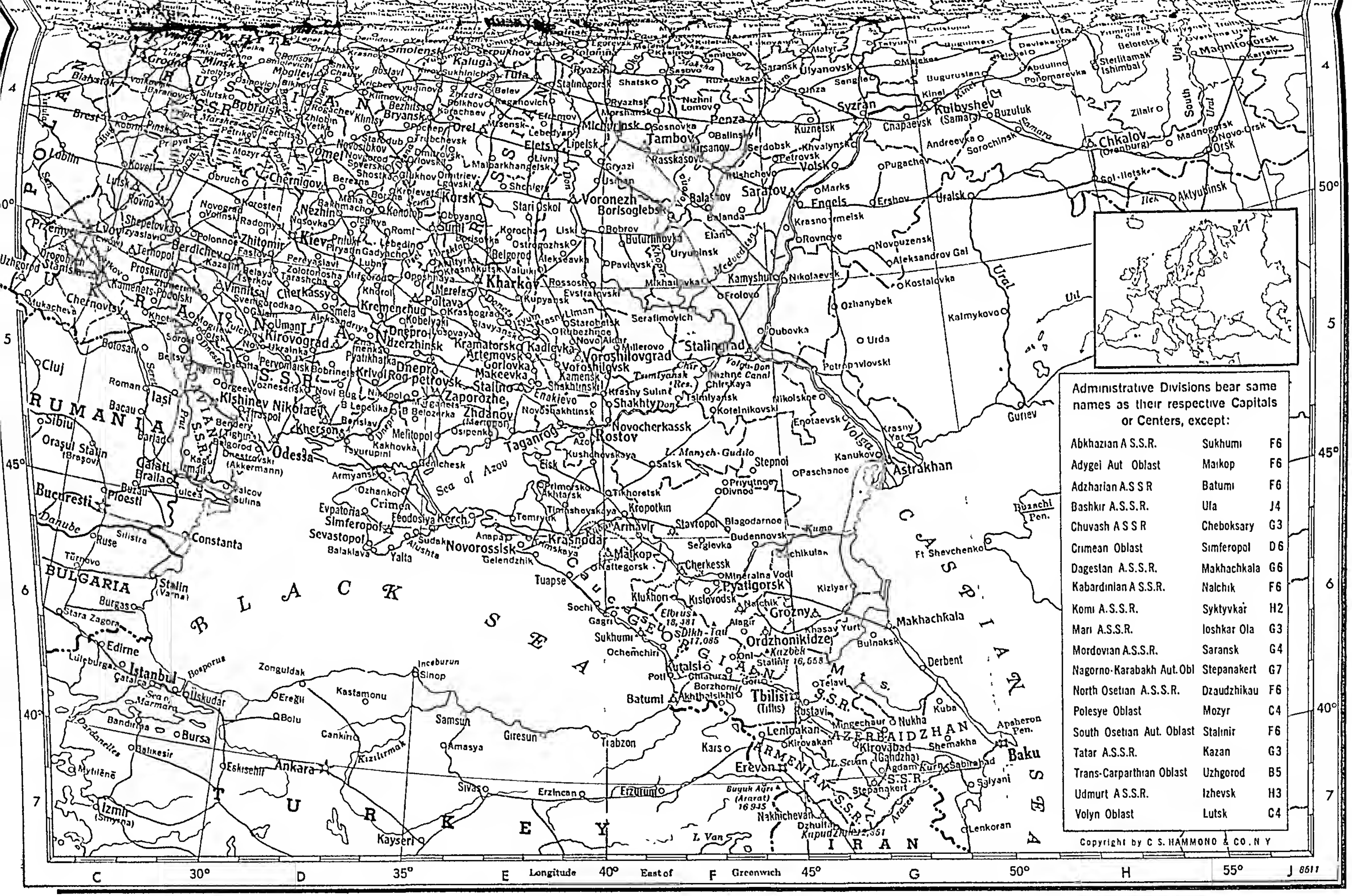
Collective farms vary in size. At first there were many small- and medium-size collectives, farmed by five to 50 families. But in 1950–51 Russia tried to tighten control of the farmers by merging these units into huge collectives, with from 500 to 3,000 families, working from 1,500 to 7,400 acres. More than 96 per cent of the peasants were put on collectives. A Communist leader supervised each giant collective.

UNION OF SOVIET SOCIALIST REPUBLICS*

(EUROPEAN PART)

Abdulino		H 4
Ahrene (Pytalovo)	1,242	C 3
Achikulak		G 6
Agdam		G 6
Agryz		H 3
Akhthalsikhi		F 6
Akhtyrka		E 4
Alagir		F 6
Alatyr	25,567	G 4
Aleksandriya	19,598	D 5
Aleksandrov		E 3
Aleksandrov Gai		G 4
Alekseevka		E 4
Alusbta		D 6
Amderma		K 1
Anapa		E 6
Andreevka		H 4
Apsberon (pen.)		H 6
Araxes (river)		G 7
Arctic		F 1
Arkhangelsk (Arcbangel)	300,000	F 2
Armavir	83,677	F 5
Armenian S.S.R.	1,345,000	F 6
Armyansk		D 5
Artemovsk	55,165	E 5
Arzamas		F 3
Asha		J 3
Astrakhan	300,000	G 5
Azerbaidzhan S.S.R.	3,100,000	G 6
Azov	19,266	E 5
Azov (sea)		E 5
Bahacvo		E 3
Bakhmach		D 4
Baku	800,000	H 6
Balakhna		F 3
Balaklava		D 6
Balanda		F 4
Balashov	31,439	F 4
Balta	21,163	C 5
Bălţi (Beltsy)	18,236	C 5
Baltic (sea)		B 3
Baranovichi (Baranowiczo)	22,848	C 4
Batumi	75,000	F 6
Belaya (river)		H 3
Belaya Tserkov		C 5
Belebei		H 4
Belev		E 4
Belgorod		E 4
Belgorod-Dnestrovski	7,766	C 5
Belinsky		F 4
Beloe (lake)		E 2
Belomorsk		D 2
Beloretsk		J 4
Belozersk		E 3
Beltsy (Bălţi)	18,236	C 5
Belyi		D 3
Bendery (Tighina)	15,075	C 5
Berdichev	66,306	C 5
Berezina (river)		C 4
Berezna		D 4
Berislav		D 5
Bezbetsk		E 3
Bezhitsa	82,331	D 4
Bikhov		C 4
Birsk		J 3
Black (sea)		D 6
Blagodarnoe		F 5
Bobrinets		D 5
Bobrov		F 4
Bobruisk	80,000	C 4
Bogoroditsk	7,180	E 4
Boikhov		E 4
Bologoe		D 3
Bolsboi Belozerka		D 5
Bolsboi Lepetika		D 5
Bolshoi Manyeh (lagoon)		F 5
Borisoglebsk	52,055	F 4
Borisov	33,426	C 4
Borisovka		E 4
Borovichi	28,400	D 3
Borzhomi		F 6
Borzna		D 4
Brest (Brześć-Nad-Bugiem)	60,000	B 4
Bryansk	87,473	D 4
Budennovsk		F 6
Bug (river)		B 4
Bug (river)		D 5
Buguima		H 4
Buguruslan		H 4
Bui		F 3
Buinaksk		G 6
Buturlinovka		F 4
Buzuluk	30,400	H 4
Byelo (White) Russian S.S.R.	7,220,000	C 4
Cahul (Kagul)	7,375	C 5
Caspian (sea)		G 6
Caucasus (mts.)		F 6
Cernăuti (Chernovtsy)	78,825	C 5
Cēsis (Tsesis)	8,748	C 3
Chagoda		E 3
Chapaevsk	57,995	G 4
Chausy		D 4
Cheboksary	12,006	G 3
Cherepovets		E 3
Cherkassy	51,693	D 5
Cherkessk	21,954	F 6
Chernigov	67,356	D 4
Chernovtsy (Cernăuti)	78,825	C 5
Cheshskaya (bay)		G 1
Chiatura		F 6
Chair (river)		F 5
Chisinău (Kishinev)	110,000	C 5
Chistopol		H 3
Chizha		F 1
Chkalov (Orenburg)	200,000	J 4
Chortkov (Czortków)	18,343	B 5
Chudovo		D 3
Chukhloma		F 3
Crimea (pen.)	1,050,000	D 5
Czortków (Chortkov)	18,343	B 5
Danilov		F 3
Daugavpils (Dvinsk)	45,000	C 3
Davlekanovo		H 4
Demidov		D 3
Derbent	27,476	G 6
Desna (river)		D 4
Dikh-Tau (mt.)		F 6
Divnoe		F 5
Dmitriev-Lgouski		E 4
Dmitrov		E 3
Dmitrovsk-Orlovski		E 4
Dnepr (Dnieper) (river)		D 5
Dneprodzerzhinsk	147,829	D 5
Dnepropetrovsk	500,000	D 5
Dnestr (Dniester) (river)		C 5
Dno		D 3
Dolgi (island)		J 1
Don (river)		F 5
Donets (river)		E 5
Drogobych (Drohobycz)	32,622	B 5
Dubovka		G 5
Dvina (bay)		E 1
Dvina (river)		C 3
Dzaudzhikau (Ordzbonikidze)	127,172	F 6
Dzerzhinsk	103,415	F 3
Dzhankoi		D 5
Dzhulfa		G 7
Dzisna	4,788	C 3
Efremov	20,341	E 4
Egorevsk	56,340	E 3
Eisk		E 5
Elabuga		H 3
Elan		F 4
Elbrus (mt.)		F 6
Elets	50,888	E 4
Enakievo	88,246	E 5
Engels	73,279	G 4
Enotaevsk		G 5
Erivan	255,000	F 6
Ershovo		G 4
Estonian S.S.R	1,000,000	C 3
Evapatoria		D 5
Evstratovski		E 5
Fastov		C 4
Feodosiya		D 5
Finland (gulf)		C 3
Frolovo		F 5
Furmanov		F 3
Gadyach		D 4
Gagri		E 6
Gaisin		C 5
Galich		F 3
Gelendzhik		E 6
Genichesk		E 5
Georgian S.S.R.	3,555,000	F 6
Glazov		H 3
Glubokoe (Głębokie)	7,544	C 3
Glukhov		D 4
Gomel	120,000	D 4
Gori		F 6
Gorka		G 2
Gorki (Nizhni Novgorod)	900,000	F 3
Gorlovka	108,693	E 5
Gorodets		F 3
Gorodok		D 3
Goryn (river)		C 4
Grodno	60,000	B 4
Grozny	172,468	G 6
Gryazi		F 4
Gryazovets		F 3
Gus Krustalny		F 3
Gzhatsk		D 3
Hiiumaa (Dagö, Khiuma) (island)		B-3
Hotin (Khotin)	7,579	C 5
Iehnya		D 4
Ilek (river)		J 4
Iletskaya Zashita		J 4
Ilmen (lake)		D 3
Imandra (lake)		D 1
Indiga		G 1
Inza		G 4
Iokanga		E 1
Ioshkar Ola	8,219	G 3
Ishimbai		J 4
Ivanovo	300,000	F 3
Izhevsk	200,000	H 3
Izhma		H 1
Izhma (river)		H 2
Izmail (Ismail)	17,569	C 5
Izyaslavl		C 4
Izyum		E 5
Jaunlatgale (Pytalovo, Abrene)	1,242	C 3
Jelgava (Yelgava)	34,099	B 3
Kadievka (Sergo)	68,360	E 5
Kadnikhov		F 3
Kaganovich		E 4
Kagul (Cahul)	7,375	C 5
Kakhovka		D 5
Kakisalmi (Priozersk)	4,132	D 2
Kalinin (Tver)	300,000	E 3
Kaliningrad (Königsberg)	150,000	B 4
Kaluga	89,484	E 4
Kalyazin		E 3
Kama (river)		H 2
Kaments'-Podolski	33,035	C 5
Kamensk-Shakhtinski		F 5
Kamyshin		F 4
Kanash		G 3
Kandalaksha	7,799	D 1
Kandalaksha (gulf)		D 1
Kanin (pen.)		G 1
Kanin (point)		F 1
Kanukov		G 5
Kapudzhik (mt.)		G 7
Kara (sea)		K 1
Kara (strait)		J 1
Karachaev		E 4
Karelo-Finnish S.S.R.	600,000	D 2
Kargopol		E 2
Karpogory		F 2
Kashira		E 4
Kasimov		F 4
Kaunas (Kovno)	105,370	B 4
Kazan	500,000	G 3
Kazatin		C 5
Kazbek (mt.)		F 6
Kem		D 2
Kerch	104,471	E 5
Kestenga		D 1
Khabarovo		K 1
Khalturin		G 3
Kharkov	900,000	E 5
Kharovsk		F 3
Khasav Yurt		G 6
Kherson	97,186	D 5
Kholm		D 3
Kholmogori		F 2
Khoper (river)		F 4
Khorol		D 5
Khotin (Hotin)	7,579	C 5
Khvalynsk		G 4
Kiev	900,000	D 4
Kildin (island)		D 1
Kimry		E 3
Kinel		H 4
Kinel (river)		H 4
Kineshma	75,378	F 3
Kingisepp		C 3
Kirillov		E 2
Kirov		D 4
Kirov (Viatka)	250,000	G 3
Kirovabad (Gandzha)	110,000	G 6
Kirovakan		F 6
Kirovograd	100,331	D 5
Kirovsk	29,000	D 1
Kirsanov	23,546	F 4
Kishinev (Chisinău)	110,000	C 5
Kislovodsk	51,289	F 6
Kizlyar		G 6
Klaipeda (Memel)	48,545	B 3
Klimovichi		D 4
Klintsy		D 4
Klukhori	2,848	F 6
Kobelyaki		D 5
Kobrin (Kobryn)	10,101	B 4
Kola (pen.)		E 1
Kolguev (island)		G 1
Kologriv		F 3
Kolomna	75,139	E 4
Kolva (river)		J 1
Kondopogo		D 2
Königsberg (Kaliningrad)	150,000	B 4
Konosha		F 2
Konotop	36,186	D 4
Korocha		E 4
Korosten		C 4
Koslan		G 2
Kostroma	150,000	F 3
Kosyarvom		K 1
Kotelnich		G 3
Kotelnikovski		F 5
Kotlas		G 2
Kovda		D 1
Kovel (Kowel)	27,650	C 4
Kovrov	67,163	F 3
Kozhva		J 1
Kramatorsk	93,350	E 5
Krasnoarmeisk (Baltser)		G 4
Krasnodar	200,000	E 6
Krasnograd		E 5
Krasnokutsk		E 4
Krasnoye		D 4
Krasny Liman		E 5
Krasny Sulin		F 5
Krasny Yar		G 5
Kremenchug	89,553	D 5
Kriehev		D 4
Krimskaya		E 6
Krivoi Rog	200,000	D 5
Krolevets		D 4
Kronshtadt		C 2
Kropotkin		F 5
Krustpils	3,658	C 3
Kuba		G 6
Kuban (river)		E 5
Kubenskoe (lake)		E 3
Kuibyshev (Samara)	600,000	H 4
Kuito (lake)		D 2
Kulebaki		F 3
Kultbaza		H 1
Kuma (river)		G 5
Kuolayarvi (Kuolajärvi)		D 1
Kupyansk		E 5
Kura (river)		G 6
Kursk	119,972	E 4
Kushchevskaya		E 5
Kutaisi	90,000	F 6
Kuznetsk	34,000	G 4
Kuzomen		E 1
Lacha (lake)		E 2
Ladoga (lake)		D 2
Lagan		G 5
Laisk		G 2
Latvian S.S.R.	1,800,000	B 3
Lebedin		D 4
Lebedyan		E 4
Lemtibozh		J 2
Lendery		D 2
Leninakan	75,000	F 6
Leningrad	3,300,000	C 3
Leninsk		E 3
Leninsk		G 5
Lenkoran		G 7
Lepel		C 4
Leshukonskoe		G 2
Lesnoi		D 1
Lida	19,490	C 4
Liepāja (Lepaya)	75,000	B 3
Likhoslavl		E 3
Lipetsk	66,625	E 4
Lithuanian S.S.R	2,700,000	B 3
Livny		E 4
Lodeinoe Pole		D 2
Losovaya		E 5
Lovat (river)		D 3
Lovozero		D 1
Lubny		D 4
Luga	24,200	C 3
Lukoyanov		F 3
Lutsk (Luck)	35,700	B 4
Lvov (Lwów)	400,000	B 5
Lyskovo		F 3
Lyudinovo		D 4
Maan Selkä (mts.)		C 1
Madona	2,357	C 3
Maikop	67,302	F 6
Makarev		F 3
Makeevka	300,000	E 5
Makhachkala	86,847	G 6
Malaya Vishera		D 3
Malmyzh		G 3
Maloarkhangelsk		E 4
Marganets		D 5
Mariupol (Zhdanov)	200,000	E 5
Mariyampole (Mariampole)	8,879	B 4
Marks		G 4
Mednogorsk		J 4
Medveditsa (river)		F 4
Medvezhegorsk		D 2
Mejdusharski (island)		H 1
Melekes		G 4
Melenki		F 3
Melitopol	75,735	D 5
Memel (Klaypeda)	48,545	B 3
Mena		D 4
Menzelinsk		H 3
Merefa		E 5
Mezen (gulf)		F 1
Mezen		F 1
Mezen (river)		G 1
Michurinsk	70,202	E 4
Middle Ural (mts.)		J 2
Mikhailovka		F 4
Millerovo		F 5
Mineralne Vodi		F 6
Mingechaur		G 6
Minsk	231,000	C 4
Mirgorod		D 5


UNION OF SOVIET SOCIALIST REPUBLICS
European Part
CONIC PROJECTION
SCALE OF MILES
0 50 100 200 300
SCALE OF KILOMETRES
0 50 100 200 300
National Capitals
Capitals of Union Republics
Administrative Centers
International boundaries
Union Republic boundaries
A S S R , Oblast, Kray boundaries
Autonomous Oblast boundaries
Canals
Railroads
The government of the United States does not recognize the incorporation of Estonia Latvia and Lithuania into the Soviet Union
Post war territorial changes shown on this map do not necessarily represent the final status of such boundaries Only after the signing of peace treaties can changes be considered official and definite
ARCTIC OCEAN
KARA SEA
WHITE SEA
GULF OF BOTHNIA
GULF OF OB
Gulf of Finland
Gulf of Riga
Arctic Circle
NORWAY
SWEDEN
FINLAND
ESTONIAN S.S.R.
LATVIAN S.S.R.
KARELO-FINNISH S.S.R.
RUSSIAN SOVIET FEDERATED SOCIALIST REPUBLIC
Novaya Zemlya
Kolguev I
Vaigach I
Kola Pen
Kanin Pen
Yamal Pen
Yugorski Pen
Timan Mts
North Ural Mts
Middle Ural Mts
LENINGRAD
Arkhangelsk
Murmansk
Petrozavodsk
Tallinn (Reval)
Helsinki
Stockholm
Vologda
Kirov
Kostroma
Molotov (Perm)
Sverdlovsk
Nizhni Tagil
Izhevsk
Kalinin
Syktyvkar
Lake Ladoga
L Onega
Pechora
Northern Dvina
Ob
Kama
Vyatka
10° 15° 20° 25° 30° 35° 40° 45° 50° 55° 60° 65° 70° 75°
A B C D E F G H J K L M
70° 65° 60° 55°
1 2 3


Administrative Divisions bear same names as their respective Capitals or Centers, except:
Abkhazian A.S.S.R. Sukhumi F6
Adygei Aut Oblast Maikop F6
Adzharian A.S.S.R. Batumi F6
Bashkir A.S.S.R. Ufa J4
Chuvash A.S.S.R. Cheboksary G3
Crimean Oblast Simferopol D6
Dagestan A.S.S.R. Makhachkala G6
Kabardinian A.S.S.R. Nalchik F6
Komi A.S.S.R. Syktyvkar H2
Mari A.S.S.R. Ioshkar Ola G3
Mordovian A.S.S.R. Saransk G4
Nagorno-Karabakh Aut. Obl Stepanakert G7
North Osetian A.S.S.R. Dzaudzhikau F6
Polesye Oblast Mozyr C4
South Osetian Aut. Oblast Stalinir F6
Tatar A.S.S.R. Kazan G3
Trans-Carpathian Oblast Uzhgorod B5
Udmurt A.S.S.R. Izhevsk H3
Volyn Oblast Lutsk C4
Copyright by C. S. HAMMOND & CO. N. Y.
BLACK SEA
CASPIAN SEA
Sea of Azov
RUMANIA
BULGARIA
TURKEY
IRAN
AZERBAIDZHAN S.S.R.
ARMENIAN S.S.R.
GEORGIAN S.S.R.
MOLDAVIAN S.S.R.
Stalingrad
Kharkov
Kiev
Odessa
Rostov
Voronezh
Saratov
Kuibyshev (Samara)
Chkalov (Orenburg)
Astrakhan
Baku
Tbilisi (Tiflis)
Istanbul
Ankara
Bucuresti
Longitude East of Greenwich
30° 35° 40° 45° 50° 55°
C D E F G H J
J 8611

Mogilev Podolski		C 5
Mogilev	80,000	C 4
Moksha (river)		F 4
Moldavian S.S.R.	2,660,000	C 5
Molodechno (Molodeczno)	5,964	C 4
Molotovsk		E 2
Molotovsk		H 3
Monchegorsk		D 1
Morozova		D 3
Morshansk		F 4
Moskva (Moscow) (cap.)	4,500,000	E 3
Mozhaisk		E 3
Mozhga		H 3
Mozyr		C 4
Msta (river)		D 3
Mtsensk		E 4
Mukachevo (Mukačevo)	26,123	B 5
Murashi		G 3
Murmansk	150,000	D 1
Murom	26,837	F 3
Nakhichevan	11,742	F 7
Nalchik		F 6
Naro-Fominsk		E 3
Narva	23,512	C 3
Naryan Mar		H 1
Neftegorsk		F 6
Neman (Nieman) (river)		B 4
Nevel		D 3
Neya		F 3
Nezhin	41,406	D 4
Nikel		D 1
Nikitinka		D 3
Nikolaev	200,000	D 5
Nikolaevsk		G 4
Nikolsk		G 3
Nikolskoe		G 5
Nikopol	57,841	D 5
Nivski		D 1
Nizhnyaya Pesha		G 1
Nizhne Chirskaya		F 5
Nizhni Lomov		F 4
Nizhni Novgorod (Gorki)	000,000	F 3
Noginsk	81,024	E 3
North Ural (mts.)		K 1
Northern Dvina (river)		F 2
Nosovka		D 4
Novaya Zemlya (islands)		H 1
Novgorod	37,300	D 3
Novgorod Severski		D 4
Novi Bug		D 5
Novo Aidar		E 5
Novo Astrakhan		E 5
Novo-Orsk		J 4
Novo Ukrainka		D 5
Novocherkassk	81,286	F 5
Novograd Volinski		C 4
Novokhopersk		F 4
Novorossisk	95,280	E 6
Novoshakhtinsk		E 5
Novosilkov	19,345	D 4
Novouzensk		G 4
Nukha	26,262	G 6
Nyandoma		F 2
Nyukhcha		G 2
Nyuvchym		H 2
Oboyan		E 4
Obruch		C 4
Ob'yachevo		G 2
Ochemchiri		F 6
Odessa	600,000	D 5
Oka (river)		F 4
Okulovski Zavod		F 1
Olonets		D 2
Omutinsk		H 3
Onega		E 2
Onega (bay)		E 2
Onega (lake)		E 2
Onega (river)		E 2
Oni		F 6
Opochka		C 3
Oposhnaya		D 4
Ordzhonikidze	127,172	F 6
Orekhovo Zuovo	99,329	E 3
Orel	110,567	E 4
Orgeyev (Orheiu)	10,504	C 5
Orsha	31,308	C 4
Orsk	100,000	J 4
Osipenko (Berdyansk)	51,664	E 5
Osipovichi		C 4
Ostashkov		D 3
Ostrogozhsk		E 4
Ostrov		C 3
Pai Yar (mt.)		K 1
Paikhoi (pen.)		K 1
Paldiski	851	B 3
Panevežys (Panevezhis)	23,947	B 3
Pärnu (Pyarnu)	20,334	B 3
Pavlovo		F 3
Pavlovsk		F 4
Pechenga (Petsamo)		D 1
Pechora (river)		H 1
[illegible]pus (lake)		C 3
[illegible]	250,000	F 4
Pereyaslavl		D 4
Pervomaisk		D 5
Peschanoe (Yashkul)		G 5
Petrikov		C 4
Petrovsk	17,312	G 4
Petrozavodsk	69,728	D 2
Petsamo (Pechenga)		D 1
Pinega		F 2
Pinega (river)		G 2
Pinsk	31,913	C 4
Piryatin		D 4
Plesetsk		F 2
Pochep		D 4
Podolsk	72,422	E 3
Polonnoe		C 4
Polotsk	24,816	C 3
Poltava	130,305	E 5
Polyarni		D 1
Ponoi		F 1
Ponoi (river)		E 1
Ponomarevka		H 4
Porkhov		C 3
Porkkala (pen.)		B 3
Postavy (Postawy)		C 3
Poti	16,671	F 6
Povenets		E 2
Priluki	28,754	D 4
Primorsko Akhtarskaya		E 5
Priozersk (Kakisalmi)	4,132	D 2
Pripet (marsh)		C 4
Pripyat (Pripet) (river)		C 4
Priyutnoe		F 5
Proskurov	28,251	C 5
Prut (Pruth) (river)		C 5
Psel (river)		D 4
Pskov	59,898	C 3
Pudozh		E 2
Pugachev		G 4
Pushkin	45,700	D 3
Pyarnu (Pärnu)	20,334	B 3
Pyatigorsk	62,875	F 6
Pyatikhatka		D 5
Pytalovo (Jaunlatgale, Abrene)	1,242	C 3
Radomysl		C 4
Rakvere	10,027	C 3
Rasskasovo		F 4
Rechitsa		C 4
Rezekne	13,131	C 3
Riga	390,000	B 3
Riga (gulf)		B 3
Rogachev		D 4
Romi		D 4
Roslavl	28,974	D 4
Rossosh		E 4
Rostov		E 3
Rostov	500,000	F 5
Rosvinskoe		H 1
Rovno (Równe)	40,788	C 4
Rovnoye		G 4
Rtishchevo		F 4
Ruchi		F 1
Rudnichni		H 3
Rugozero		D 2
Russian Sov. Fed. Soc. Rep.	111,000,000	F 3
Russki (cape)		H 1
Rustavi	50,000	G 6
Ruzaevka		F 4
Ryazan	95,358	E 4
Ryazhsk		F 4
Rybachi (pen.)		D 1
Rybinsk (reservoir)		E 3
Rybnitsa		C 5
Rzhev	54,081	D 3
Saaremaa (Ösel, Sarema) (island)		B 3
Sabirabad		G 6
Salsk		F 5
Salyani		G 7
Samara (river)		H 4
Samoded		F 2
Samtredia		F 6
Saransk		G 4
Sarapul	32,400	H 3
Saratov	500,000	G 4
Sasovo		F 4
Sebezh		C 3
Seg (lake)		D 2
Seim (river)		D 4
Semenov		F 3
Semenovskoe		F 2
Sengile		G 4
Serafimovich		F 5
Serdobsk		F 4
Sergievka		F 6
Serpukhov	90,766	E 4
Sestroretsk		C 2
Sevan (lake)		G 6
Sevastopol	111,946	D 6
Shakhty	155,081	F 5
Shakuiya		G 3
Sharya		G 3
Shatsk		F 4
Shatura		E 3
Shcherbakov (Rybinsk)	150,000	E 3
Shemakha		G 6
Shenkursk		F 2
Shepetovka		C 4
Shigri		E 4
Shklov		D 4
Shoina		F 1
Shostka		D 4
Shumerlya		G 3
Shuya	57,950	F 3
Šiauliai (Shaulyay)	35,000	B 3
Simferopol	142,678	D 6
Sisola (river)		H 2
Slavyansk	75,542	E 5
Slobodskoi		H 3
Slutsk		C 4
Smela		D 5
Smolensk	150,000	D 4
Smolevichi		C 4
Sochi		E 6
Sokol		F 3
Soligalich		F 3
Solovetski (islands)		E 1
Solvychegodsk		G 2
Sorochinsk		H 4
Soroki (Soroca)	8,042	C 5
Sortavala (Serdohol)	4,528	D 2
Sosnovka		F 4
South Ural (mts.)		J 4
Sovetsk		G 3
Sovetsk (Tilsit)	57,244	B 4
Stalingrad	400,000	F 5
Stalinir	7,333	F 6
Stalino	500,000	E 5
Stalinogorsk	76,207	E 4
Stanislav (Stanisławów)	60,256	B 5
Staraya Russa	26,700	D 3
Stari Oskol	26,697	E 4
Staritsa		D 3
Starobelsk		E 5
Starodub		D 4
Stavropol (Voroshilovsk)	85,100	F 5
Stepanakert	5,436	G 7
Stepnoi (Elista)		F 5
Sterlitamak	25,155	J 4
Stolbtsy (Stolpce)	6,278	C 4
Storozhevsk		H 2
Suda (river)		E 3
Sudak		E 6
Sukhinichi		E 4
Sukhona (river)		F 2
Sukhumi	28,136	F 6
Sumi	63,883	E 4
Sura (river)		G 4
Svenigorodka		D 5
Svir (river)		D 2
Svoboda		E 4
Sychevka		D 3
Syktyvkar		H 2
Syzran	150,000	G 4
Taganrog	150,000	E 5
Tallinn (Revel)	190,000	B 3
Tambov	150,000	F 4
Tarashcha		D 5
Tartu (Yurev)	50,000	C 3
Taurage	6,720	B 3
Tbilisi (Tiflis)	540,000	G 6
Teikovo		E 3
Telav		G 6
Telshay (Telsiai)	5,691	B 3
Temnikov		F 4
Temryuk		E 5
Teriberka		E 1
Ternopol (Tarnopol)	35,831	C 5
Tetyushi		G 4
Tiflis (Tbilisi)	540,000	G 6
Tighina (Bendery)	15,075	C 5
Tikhoretsk		F 5
Tikhvin		D 3
Tilsit (Sovetsk)	57,244	B 4
Timan (mts.)		H 1
Timashevskaya		E 5
Tiraspol	25,748	C 5
Tirlyanski		J 4
Top (lake)		D 1
Toropets		D 3
Torzhok		D 3
Totma		F 3
Troitsko Pechorskoe		J 2
Trubchevsk		D 4
Tsesis (Cēsis)	8,748	C 3
Tsimlyansk		F 5
Tsyurupini		D 5
Tuapse		E 6
Tukums	8,144	B 3
Tula	300,000	E 4
Tulchin		C 5
Tuloma (river)		D 1
Tutaev		E 3
Tver (Kalinin)	300,000	E 3
Ufa	300,000	J 4
Ufa (river)		J 3
Uglich		E 3
Ukhta		D 1
Ukhta		H 2
Ukmerge	13,104	B 3
Ukrainian S.S.R. (incl. Crimea)	41,550,000	D 5
Ulyanovsk	200,000	G 4
Uman	40,471	C 5
Unja (river)		F 3
Ural (mts.)		J 2
Ural (river)		J 4
Uryupinsk		F 4
Urzhum		G 3
Usa (river)		K 1
Usman		F 4
Ust-Kulom		H 2
Ust Pinega		F 2
Ust Shugor		J 2
Ust Tsilma		H 1
Ust Usa		J 1
Ust Vorkuta		K 1
Ust Vym		H 2
Ustyuzhna		E 3
Utyana (Utena)	5,890	C 3
Uzhgorod (Uzhorod)	26,669	B 5
Vaga (river)		F 2
Vaigach (island)		K 1
Valdai		D 3
Valdai (hills)		D 3
Valga	10,842	C 3
Valmera (Valmiera)	8,482	C 3
Valuiki		E 4
Vazhgori		G 2
Velikaya (river)		C 3
Velikie Luki	26,474	D 3
Veliki Ustyug	23,382	G 2
Velikovisochnoe		H 1
Velizh		D 3
Velsk		F 2
Ventspils	15,679	B 3
Verkhne Toima		G 2
Vesegonsk		E 3
Vetka		D 4
Vetluga		G 3
Vetluga (river)		G 3
Viatka (Kirov)	250,000	G 3
Vichuga		F 3
Viipuri (Vyborg)	71,944	C 2
Vileika (Wilejka)	5,595	C 4
Vilnius (Vilna)	163,000	C 4
Vinnitsa	92,868	C 5
Vitebsk	80,000	C 3
Vladimirovka		G 5
Vladimir	66,761	F 3
Vodi (lake)		E 2
Volga (river)		G 5
Volga Don (canal)		F 5
Volkhov		D 3
Volkhov (river)		D 3
Volkovisk (Wołkowysk)	15,027	B 4
Volnoe		G 5
Vologda	95,194	F 3
Volsk	55,053	G 4
Vorkuta		K 1
Vorona (river)		F 4
Voronezh	300,000	E 4
Voroshilovgrad	200,000	E 5
Voroshilovsk	54,794	E 5
Vorskla (river)		E 4
Votkinsk		H 3
Vozhe (lake)		F 2
Vozhega		F 2
Voznesensk	7,830	D 5
Vyatka (river)		H 3
Vyazma		D 3
Vyborg (Viipuri)	71,944	C 2
Vychegda (river)		G 2
Vyg (lake)		E 2
Vyksa		F 3
Vym (river)		H 2
Vyshni-Volochek	63,642	D 3
Vytegra		E 2
White (Byelo) Russian S.S.R.	7,220,000	C 4
White (sea)		E 1
Wilejka (Vileyka)	5,595	C 4
Wołkowysk (Volkovisk)	15,027	B 4
Yalta		D 6
Yaman (mt.)		J 4
Yanaul		J 3
Yaransk		G 3
Yarensk		G 2
Yaroslavl	300,000	E 3
Yartsevo		D 3
Yelgava (Jelgava)	34,099	B 3
Yug (river)		G 2
Yukhnov		D 4
Yurevets		F 3
Zagorsk		E 3
Zaporozhe	300,000	E 5
Zelenodolsk		G 3
Zhdanov (Mariupol)	200,000	E 5
Zhitomir	95,090	C 4
Zhizdra		E 4
Zhlobin		D 4
Zhmerinka		C 5
Zilair		J 4
Znamenka		D 5
Zolotonosha		D 5

Some collective farms cover tens of thousands of acres. A farm of this type is called a *state* farm (*sovhoz*). Each one is run like a big factory by a manager appointed by the government. Some are experimental farms. State farms occupy about one-tenth of Russia's total farm acreage.

A huge army of officials (the farm bureaucracy) is needed to operate the collectives. The machine-tractor stations supply each farm with managers, technicians, scientists, and bookkeepers. After the second World War corruption was found to be flourishing on the collectives. Farmers tilled state lands privately and withheld produce from the government. The government found it necessary to create a new board numbering thousands to supervise the farm bureaucracy. In 1947 this board dismissed half a million farm officials from their posts for corruption.

City Workers under Communism

City workers had experiences resembling those of the peasants. In 1917 they formed *soviets* and helped to win the Revolution. They also accepted Communist leadership in the patient Russian way. But they did not gain richer lives.

Old Russia had modern textile factories in Moscow and Leningrad and a large iron industry in the Ukraine. But most manufacturing was done by hand. Peasants made their own tools, wove their own linen, and carved their own wooden spoons and bowls. But the Communists wanted to create a fully developed machine age in Russia almost immediately. This meant forcing through within a few years an industrial revolution such as had taken a century in Great Britain and the United States.

The government plans called for building up heavy industry to supply the farms with tractors and the army with guns, tanks, and planes. American engineers were brought in to build giant factories and install the newest machinery. Technical schools were set up to train the workmen. The supply of new housing, furniture, clothing, and hundreds of other articles that make living comfortable was held to the minimum. *Real wages* (what the worker could buy with his weekly pay) declined about 50 per cent between 1928 and 1948. Workingmen could no longer support their families. To make ends meet, their wives went into industry—even heavy industry and mines. Thirty years after the Revolution people on relief in the United States had a higher standard of living than the Russian worker.

Incentives for Workers

At first, all workers were paid the same wage. But production was miserably low. Then factory work was put on a piece work system and bonuses were paid for output above the average. A miner, Alexis Stakhanov, with his group, hewed 14 times the usual amount of coal by specializing tasks as miners did in Western countries. The government celebrated his achievement and heaped bonuses and honors on other workers (called *stakhanovites*) who speeded up production. In 1948 a shoe worker was made a national hero because he built platforms so workers could reach the machines.

Life in the Crowded Cities

Before the Revolution three-fourths of the people lived on the land. Within a few decades a majority of the population was living in towns. The result was fantastic overcrowding. The government made plans for housing, but building proceeded very slowly.

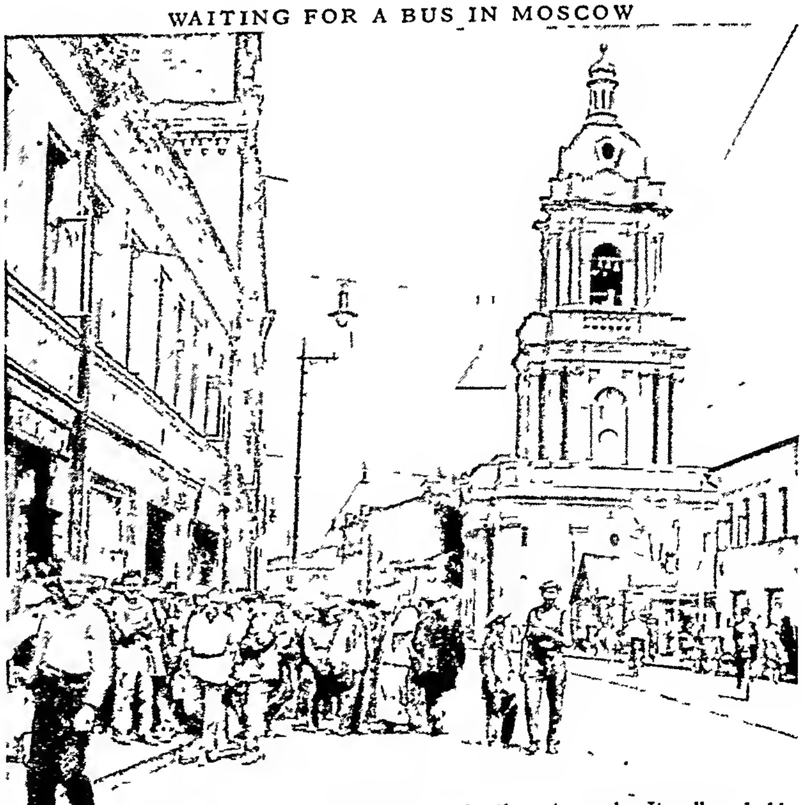
In apartment houses a worker's family lives in one room and shares the kitchen and bath with other families in the apartment. Many live in old wooden shacks, even in Moscow. In the newer Siberian cities thousands of workers live in dugouts and barracks.

In 1948 the government decreed that citizens might build and own their own homes up to five rooms in size. But it did not say how the houses could be built. There are no contractors because in Russia it is a crime for an individual to hire labor.

A Tour through a Russian City

The largest cities have a few fine boulevards, even eight lanes wide. But most streets are narrow and twisting (often ending in blind alleys) and paved

WAITING FOR A BUS IN MOSCOW



These people are waiting for a trolley bus to take them to work. It will probably be full when it arrives, since there are not enough busses in Moscow.

with cobblestones. In the center of Moscow one now sees many new automobiles. These are the property of the bureaucrats; the workers cannot afford to buy them. There are few electric signs, except over theaters. Propaganda posters take the place of billboards; and almost every park displays a huge statue of Lenin or Stalin.

Most of the people on the street look shabby and their clothes make no pretense of style. Women wear berets or shawls on their heads. The men (usually beardless but unshaven) wear caps. Leather shoes are scarce. Women wear canvas shoes and even bedroom slippers on the street.

All stores are owned and run by the government. Rationing was abandoned in 1947; but clothes and most household articles are still in short supply. When a store receives a shipment of some scarce article, people stand in long queues for hours waiting to buy. Many of them leave empty-handed, either because the stock is exhausted or because they cannot afford the high prices.

Prices are fixed by the government and are high, for they contain a hidden turnover (sales) tax ranging from 50 to 90 per cent of the cost of the article. The average factory worker must labor half an hour to earn enough to buy a loaf of rye bread; four hours for a pound of beef; 20 hours for a pound of butter; and more than two months for a suit of clothes or a pair of good shoes.

Strict Control of Labor and Management

IN RUSSIA the government owns all factories, railroads, mines, and stores. "Coöperatives" (called *artels* in Russian) can make some petty articles. But even these small industries are managed by the state.

Labor discipline is severe. A worker may be dismissed for being tardy, for idling, or for being absent a single day without good cause. Several days' absence is punished with several months' imprisonment. A worker may not change his employment without permission. He may not move to another town to look for a new job; for he needs a special permit to change his place of residence and this is practically impossible to obtain. The government, however, sometimes moves the entire population of a district to Siberia. This happened to the Tatars of the Crimea and the German population in the Volga River valley.

Russia's Labor Unions

Russia has the largest labor unions in the world; membership is compulsory for all workers. But the government does not enter into contracts with its employees. Collective bargaining is unknown. Strikes are treason under the law. Communist party members run the unions. They exist mainly to indoctrinate workers with Communist propaganda, speed up production, and enforce discipline. They also administer the social security system and the factory nursery, where children are cared for while their mothers work.

Management as well as labor is subject to stern discipline. The press is forbidden to criticize the government, the top officials, or the over-all production plan for industry; but it can attack factory managers. Soviet newspapers regularly print articles complaining of inefficiency, wastage, corruption, bribery, speculation, and falsification of figures. From time to time the secret police conduct a widespread purge of factory officials and engineers.

Class Distinctions in Soviet Society

THE Revolution of 1917 destroyed the upper classes of old Russia—the aristocrats and army leaders, the middle class, the intellectuals, and the clergy. The new Russia was to be a classless society of workers and peasants, a "dictatorship of the proletariat." Lenin, the leader of the Revolution, promised the people "reduction of the pay of all, without excepting government leaders, to the regular wage scales of the workers."

Stalin found it impossible to develop industry and collective farms on the basis of equal pay. In 1934 he denounced equalitarianism as "the views of our left-wing scatterbrains." Thereafter officials and workers were to be paid according to the service they performed. The Communist goal—payment according to need, not deed—was put off to the far distant future.

Unequal pay soon gave rise to new social classes. The top class receives about a third of the national income. It is made up of party and state officials, the managers of industry, officers of the army and navy, chieftains of the secret police, scientists, writers, artists, and theatrical folk. These people live in luxurious quarters, have servants, special food, and free transportation.

The second class is made up of the workers in industry. They live in dire poverty (except for the favored Stakhanovites); but they are better paid than the third class, the peasants, who still comprise more than half the population. The lowest class of all are the wretched people in the forced-labor camps, who exist on the verge of starvation.

Slave Labor in the Soviet Union

The Soviet Union is the greatest slave state in history. Estimates of the number of people in the forced-labor camps range from 8 to 15 million. The Soviet government publishes no figures; information comes from prisoners who escaped and from Russian officials who fled the country.

Some of the slave laborers are ordinary criminals. The majority are political prisoners, accused only of opposing the Soviet régime. They are sentenced by agencies of the secret police, usually to ten years of forced labor.

Most of the camps are located in the far north and east. The camps are surrounded by barbed wire and sentry boxes. The prisoners dress in rags, are fed on a semistarvation diet, and have little medical care. They work chiefly at lumbering, in coal and gold mines, on roads, canals, and railroads, fish canning, and making shoes for the army. The camps are run by an arm of the secret police, the MVD—the largest

employer of labor in the Soviet Union. Most prisoners die before the end of their term.

Propaganda Fills Leisure Hours

A DICTATORSHIP does not let people spend their leisure hours as they like. The Central Committee of the Communist party plans all recreation activities and spreads government propaganda in the various groups. If a Russian citizen wants to play tennis, he must join a government-sponsored physical culture club. Even chess players are organized in chess circles. Any private club would be quickly broken up by the secret police.

Sports and "culture" are emphasized. Physical culture clubs claim more than 10 million members. Winter sports week offers hockey matches and figure skating exhibitions. Moscow's stupendous athletic festival in July is attended by delegates from every section.

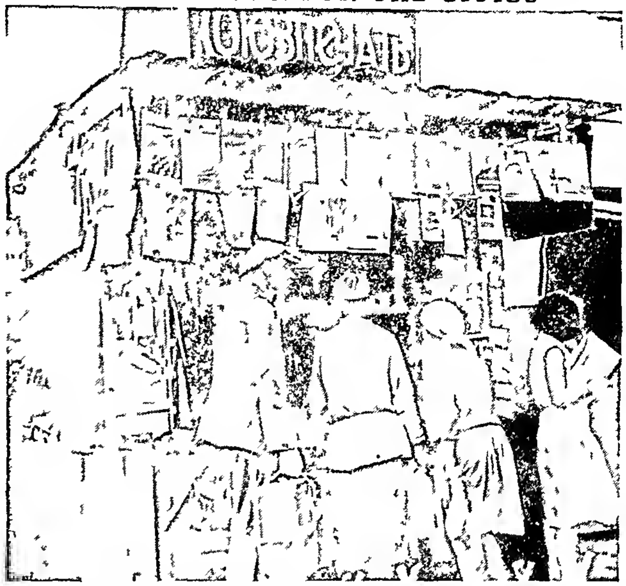
Workers spend many evenings visiting friends at Communist club rooms, called "Agitation Points." The "points" provide dance music, concerts, and plays, along with lectures and Communist literature. They are warm and bright with comfortable chairs.

The chief national holidays are November 7, the day when the Bolshevik party came to power, and May 1, International Labor Day. They are celebrated by mammoth parades in all the cities of the Soviet Union. On those days workers are organized into marching units, which carry gigantic poster-banners of Lenin and Stalin. (For picture, *see* Moscow.)

Theaters, Radio, and the Press

The Soviet government has put up theaters and moving-picture houses all over the Soviet Union. In war-ravaged Stalingrad, a huge new theater was erected before houses were built for the homeless. Films and the new plays extol the "glories" of Soviet life.

PROPAGANDA FOR THE CITIES

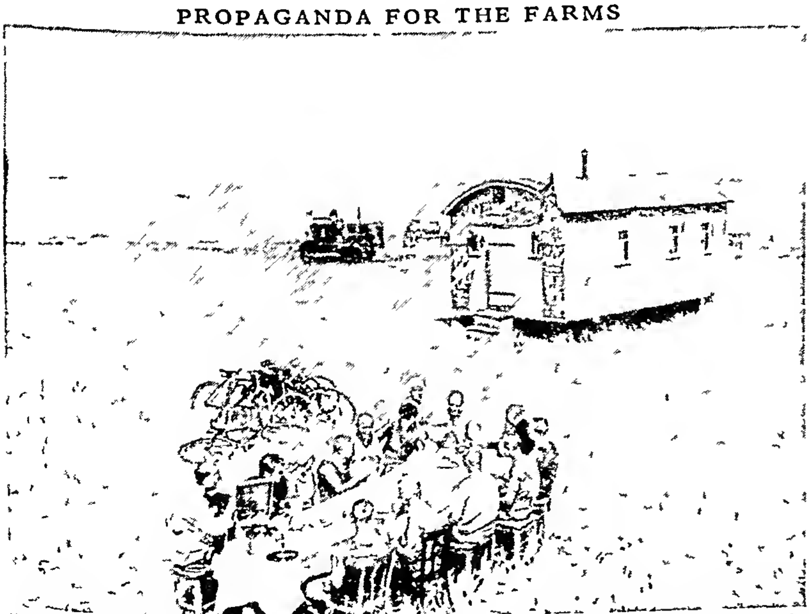


Most Muscovites prefer the small Moscow newspaper, which gives chiefly local news, to Pravda or Izvestia, which emphasize international events. All papers print official propaganda.

Newspapers are printed in 70 languages under careful censorship. There is no freedom of the press. The newspapers have no comics, no fashion news, and, of course, no sales advertisements or "help wanted" columns. *Tass*, a government agency, collects and distributes the news. The leading newspapers are *Izvestia* (News), the official spokesman of the government, and *Pravda* (Truth), the mouthpiece of the Communist party. The army also has its newspaper, *Red Star*. On important matters all newspapers speak alike.

Radio also is a government monopoly. Loudspeakers broadcast news, music, and entertainment to factories, collective-farm centers, clubs, and schools. About five million Russians have radios in their homes.

PROPAGANDA FOR THE FARMS



"Culture wagons" are towed into the fields at harvest time to bring propaganda literature to the workers. Here people from a machine-tractor station are lunching with officials of a collective farm.

Newspapers, radio, and lecturers tell the Russians repeatedly that the Soviet system is the freest and best in the world. They hear that the average American lives close to starvation; that all great scientific inventions were made by Russians, and other ideas the government wants them to believe. In 1947 the United States government began to broadcast news to Russia on its 'Voice of America' program. But it is dangerous to listen. The Russian who tunes in can never be sure that the secret police are not outside his door.

Officials travel about constantly and enjoy free transportation. For the workers, travel is severely restricted. The government made over former palaces in the sunny Crimea and the Caucasus as resorts and sanitariums "for workers"; but only government officials and Stakhanovites may spend vacations there.

RUSSIA'S MOST FAMOUS CHURCH

The Church of St. Basil the Blessed stands at the end of Red Square in Moscow. Its brightly colored towers, all different, are crowned with gilded domes. Ivan the Terrible began this church in 1554 It is now a museum.

Foreign travel is absolutely prohibited. An attempt to leave Russia is punished as a criminal offense. Only officials on state missions may visit foreign lands.

Religion before and after the Revolution

IN THE 9th and 10th centuries Christian missionaries were filtering into Russia. Vladimir, Grand Duke of Kiev and All Russia, allowed himself to be baptized in 988 and ordered the heathen temples pulled down and the wooden idols destroyed. Greek monks and priests brought with them not only their religion, but also the Cyrillic alphabet, in which Russians could write their native language (*see* Alphabet), as well as Byzantine art and architecture. Russian monks learned to paint icons on wood panels, sometimes carving them first in low relief. (The Orthodox Church forbids the use of fully sculptured figures.)

Communists Attack the Church

When the Bolsheviks came into power they brought with them the slogan of Karl Marx, "Religion is the opium of the people." They opposed all religious worship—Mohammedan, Buddhist, Jewish, and Christian. Most clergymen of the Orthodox Church were interned or killed.

In 1927 the Communist party organized a "Society of the Militant Godless." It published a weekly journal, *Byezbozhnik* (Godless) devoted to antireligious propaganda. Many monasteries and cathedrals were turned into museums of antireligious exhibits. A new six-day week abolished Sunday.

People Cling to Their Faith

Nevertheless on Easter and Christmas the few churches that remained open overflowed. In the peasant's cottage icons still stood alongside portraits of Lenin and Stalin. In 1937 the government took a census of religious believers. The results (published several years later) showed that 94 million people still clung to the Orthodox faith and 8 million to Mohammedanism. Jews, Roman Catholics, Baptists, and Lutherans accounted for another 7 million.

The government acted upon this finding. Churches and mosques were repaired and reopened. Antireligious plays and films were forbidden and bitter attacks on the church removed from school textbooks. In 1940 the seven-day week was restored, with Sunday re-established as a holiday for all. On Sept. 12, 1943, religion was officially restored with the crowning of a new "Patriarch of Moscow and All the Russians." In the same month a Mohammedan congress was convened at Tashkent. But religion was put under the direction of the Soviet Council

A CROWD OF WORSHIPERS

Unable to find room inside this Moscow church, these women have gathered below a window to hear the service. Most Russian churches have fallen into decay or been turned to other uses. Those that are open are crowded with worshipers.

of Religious Cults, headed by a veteran Communist party leader. Members of the Communist party still had to be atheists. In 1949 the general secretary of the Komsomols ordered the youth organization to fight religion. "Komsomols cannot be neutral concerning religion," he declared. "Komsomols are called upon to propagandize the advancement of science, and any religion is in direct conflict with science."

Easter and Christmas in the Orthodox Church

Easter (in Russian *Paskha*) ranks first among the Orthodox Church's festivals. On Saturday night every church is packed with people standing or kneeling (there are no seats in Russian churches). Choirs chant the wonderful Russian liturgy. Then mitred priests in magnificent robes leave the church followed by the choir. At midnight the priests file in followed by the choir chanting, "Christ is risen!" Bells peal out from countless belfries. Then the worshipers light the candles they have been holding from the priests' tapers, and place them before their favorite icons. Leaving the church the people greet one another with the words "Christ is risen," and old and young kiss one another on alternate cheeks three times. Then they disperse to their homes for the traditional Easter feast, which takes place about three o'clock in the morning. No Easter is complete without *kulich*, a sweet obelisk-shaped bread, and *paskha*, a pyramid of cottage cheese mixed with sugar, eggs, and raisins.

Christmas day moved up to January 7 when the Soviet government introduced the Gregorian calendar of the Western world, for the Russian Orthodox Church continued to follow the old style, or Julian calendar (*see* Calendar). Throughout the day a constant stream of people may be seen entering and leaving the churches. But in Russia, Christmas is not a legal holiday, and the gift giving and festivities of the Western countries are not held on this day.

Grandfather Frost Comes on New Year's Day

Russian children have always had their "fir-tree parties" and presents on New Year's Day. This is now a legal holiday throughout the Soviet Union.

CHILDREN OF ASIA LEARN CLASSIC BALLET

From far-off Kirghizia these boys and girls have come to Leningrad to give a concert. Not content with proficiency in their native dances, they have gone in for the formal ballet.

A NURSERY FOR WORKERS' CHILDREN

On their way to work in the factory, Soviet mothers deposit their babies and smaller children in a nursery. This group has just discovered a picture of Stalin in a scrapbook.

A few days before the New Year, when cities and farms are white with snow, fir trees from Russia's dense forests appear in the markets. In the stores children press close to showcases that display simple toys. Rag dolls, for which Russia has always been famous, draw the largest crowds—dolls of peasants, young and old, of Siberian hunters and Cossack shepherds. Some are puppets (*bi-ba-bo* dolls), which are slipped over the hand and worked with the fingers. Stuffed polar bears and brown bears, cats, elephants, and foxes also find admirers.

On New Year's eve brightly lit fir trees gaily decorated with tinsel are set up in the parks and squares. Huge "fir tree parties" are given for the children in Pioneer clubs, in factories, and in trade-union houses. Grandfather Frost appears from behind the tree, bearded and kindly like Santa Claus, but dressed in white. Russia's Snow Maiden—a blonde young girl in white with a wreath on her head and a white veil over her face—helps him to unload his pack of candy, cakes, picture books, and handkerchiefs. Then Grandfather Frost, a great comedian, directs the old-time children's games: Rimski Papa (literally, Roman pope), which resembles Going to Jerusalem; blindman's buff; hide-and-seek; and "Who am I?" The children sing old traditional songs like "The Little Fir Tree" to the accompaniment of a Young Pioneer orchestra. Storytellers read Pushkin's 'Golden Fish' or other beloved fairy tales. Sometimes professional performers appear to entertain the children with a ballet or a scene from a play.

Education in the Soviet Union

CHILDREN are taught that their first loyalty is to the state rather than to their parents. The state takes entire charge of their education, decides what trade or profession they shall follow, and supervises their recreation and sports. They spend little time in the home. When a mother goes to work, she leaves her younger children (ages three to six) at a kindergarten. She takes the baby with

ASSEMBLED FOR THE MAY DAY PARADE

Here Young Communists (Komsomols) stand ready for a May Day parade. They will carry with them the huge picture of Stalin and Molotov surrounded by children. Like the Young Pioneers, these girls wear red scarves, the badge of membership.

her to the factory to be cared for in a *crèche* (nursery) while she works.

Children begin school at the age of seven. Country schools have seven-year courses. The cities have some ten-year schools, including three years of high school. The better schools are reserved for children of upper-class families.

All Soviet schools stress obedience and service to the state. Textbooks and curriculum are uniform throughout the Soviet Union. Russian history and Soviet achievements in science, literature, and art are emphasized. Russian children learn almost nothing about life in other countries. Non-Russian children speak their native language in school but study Russian as well. Girls and boys attend separate classes. Both are trained in manual skills. Physical training is given in gymnasiums. Sports include volley ball, football, basketball, tennis, skating, and skiing. Boys begin military training early.

Higher Education and Labor Reserves

Education up to the age of 14 is free and compulsory. For higher education students pay fees. (Free higher education was abolished in 1940.) Scholarships are granted to the most capable children.

Children of the poor who do not win scholarships are drafted at the age of 14 into "labor reserves." By this device the state draws off boys and girls from the farms to serve in industry. "Battalions" of labor reserves are sent wherever the state needs them —often to distant Siberia. The young people are trained by the industry that employs them.

Scholarship students cannot choose their vocation. Some are selected to take short courses in a trade or industrial school. Others enter a four-year technical high school (*tekhnikum*). Graduates of tekhnikums and of the ten-year city schools are eligible to enroll in a technical institute or university. In 1947 the total enrollment in institutions of higher learning was 560,000. (The United States in the same year had about two and a half million in colleges and universities.) Soviet universities do not give a liberal all-round education. Courses are planned to meet the needs of the state rather than the interests of the individual.

In old Russia about 60 per cent of the people were illiterate. Before the second World War the Soviet government claimed to have reduced illiteracy to 20 per cent. After the war the minister of education complained that many children, especially in country districts, were getting little or no schooling.

Young Pioneers and Timurites

Practically all girls and boys between the ages of 7 and 14 are enrolled in the Young Pioneers—the largest Communist organization of all. Initiation is a solemn ceremony. The child swears loyalty to the Communist leaders and dedicates himself to the defense of his country. Then he puts on a red scarf as his badge of membership.

Within the Pioneers is a smaller society of selected children called the Timurites. They take their name from a popular children's story called 'Timur and His Gang'. Like their storybook hero, the Timurites have secret passwords and signals. The leader plans assignments for his group. The members pledge themselves to follow his orders without question.

League of Young Communists

The purpose of the Pioneers and the Timurites is to control the thoughts and conduct of children and assure their loyalty to the Soviet régime. The Komsomol (League of Young Communists) aims to enroll virtually all youth in the Soviet Union older than 14. The life of the young people centers around their Komsomol. It plans excursions, runs social clubs, organizes entertainments and dances, and arranges visits to theaters and concerts. Membership is practically indispensable for those who seek higher education or positions in the bureaucracy.

According to the first constitution, members were to leave the league at the age of 23. Many older persons, however, who could not win membership in the Communist party, remained in the league. The Komsomol therefore has many members over 40 years of age. By 1949 the total membership had grown to about 9,300,000. As in the Communist party itself, the membership is cut down from time to time by a widespread purge.

The Komsomol is controlled by the Communist party through the Komsomol secretary, called the *vozhd* (leader). He sees that the league teaches Communist doctrine and strict obedience. Above all, it trains youthful recruits for the Communist party.

Art, Science, and Industry in Soviet Russia

BYZANTINE influences colored Russia's cultural development after the 10th century. Later this tradition became fused with oriental elements when the Golden Horde of Tatars swept over the steppes. Not until the 17th century did Russia begin to look to the West for inspiration. In the 19th century Russia's culture began to influence western Europe. To the Russia of the period before the Revolution we owe one of the world's great literatures, as well as much in music, the theater, and the ballet (*see* Music; Russian Literature).

Until the 19th century Russia's outstanding artistic achievement was in the field of architecture. Its builders early showed matchless skill in using wood from the unlimited forests. Church architecture became a happy union of Slavic and Byzantine elements. The Byzantine cubic form (*see* Architecture) was broken up into a group of buildings. Round domes gave way to onion-shaped cupolas.

Later Russia borrowed from Europe the Renaissance architecture, the pretentious baroque, and the classic style for its palaces, mansions, and public buildings. Soviet Russia sought to break completely with its past and experimented with modernistic styles. Cubism, futurism, "new art," and the "heroic" styles each had its day, to be followed by strictly functional buildings inspired by the machine.

Russian Music, Drama, and Ballet

In the latter half of the 19th century genuinely Russian music became known the world over in the symphonies of Tschaikovsky (*see* Tschaikovsky). Other composers drew their inspiration from Russian folklore. Rimsky-Korsakov based his opera 'The Golden Cock' on a folk tale, and Borodin derived his 'Prince Igor' from an old heroic song. For 'Boris Gudenov' Moussorgsky drew on Russian history. The Revolution made exiles of Rachmaninoff, composer and pianist, and Stravinsky, noted for his ballet music. Prokofiev, whose simple music appealed to the masses, returned to Russia and composed music for the historical film 'Alexander Nevsky' and an opera based on Tolstoy's 'War and Peace'. Of the composers who grew up in the new Russia the first to become known abroad was Dmitri Shostakovitch, whose work combined traditional and modernist tendencies.

Before the Revolution the Moscow Art Theater had become world-famous for its dramatic realism. Each actor was perfectly trained and none starred. Plot was subordinated to character portrayal and local color. The ballet was transformed into one of the supreme expressions of Russian culture. Drawing on folklore, it enchanted audiences the world over with its fairylike pageants.

Turning Art into Propaganda

After the period of turmoil following the Revolution, the Soviet government assumed direction of all the arts. Composers, writers, painters, and sculptors became among the best paid people in the Soviet Union. Novelists, playwrights, and musicians were allowed to receive royalties. But the artist was not free. The Central Committee of the Communist party laid down the subjects that could be treated. Art was limited to Communist propaganda.

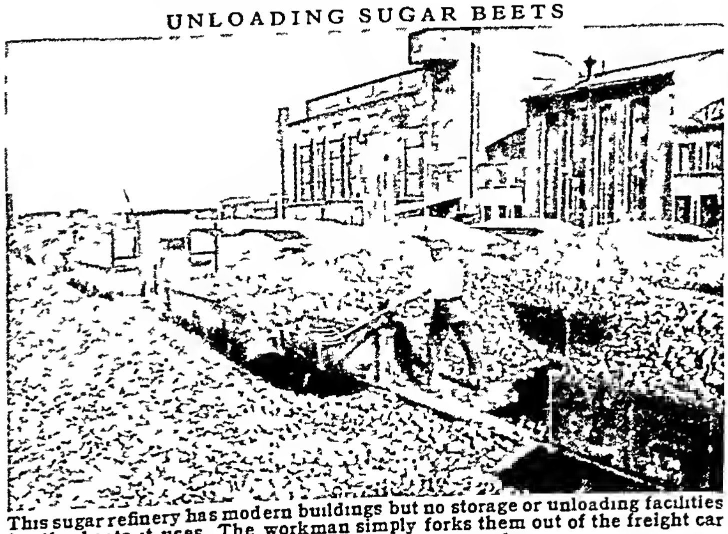
A number of writers disappeared in the purge of 1936. Other promising authors, like Konstantin Simonov, became mere propagandists. Serge Eisenstein, the famous producer, had to destroy the second part of his film on 'Ivan the Terrible'. In 1948 the Central Committee launched an attack on the "big three" Soviet composers (Dmitri Shostakovitch, Sergei Prokofiev, and Aram Khachaturian) for writing music "that strongly smells of the spirit of current modernist bourgeois music of Europe and America." "Truly Soviet" music had to be simple enough to appeal to the masses. The Russian creative genius was effectively quenched.

Science Serves the State

Under the czars Russia built up a tradition of scientific research. All the world knows of Mendeléev, the chemist, and Pavlov, the great physiologist. The Soviet government regarded science as the foundation of the state and technology as its most necessary tool. Research institutes were set up to explore the natural resources and improve industrial processes, and technicians were trained for industry.

Scientists were soon hampered by dictatorial policy. The quantum theory of physics and the theory of relativity were out of favor because they conflicted with Marxian doctrine. Plant breeders got into trouble for following the science of heredity fathered by Gregor Mendel. Nikolai Vavilov, the foremost Russian geneticist, died in a concentration camp in Siberia in 1942. In 1948 more noted biologists lost their posts. Others recanted, denounced the science of heredity, and promised to limit their research to the theory of acquired characteristics.

UNLOADING SUGAR BEETS



This sugar refinery has modern buildings but no storage or unloading facilities for the beets it uses. The workman simply forks them out of the freight car and dumps them on the ground.

Farms and Forests, Mines and Factories

ALTHOUGH Russia covers an area almost three times as great as the United States, the amount of fertile farmland in the two countries is about equal. Russia, however, has many more acres under cultivation, for it is the policy of the government to utilize as much land as possible. Soil is farmed in Russia that would be abandoned in the United States as unprofitable.

Most of Russia's food is raised on the "fertile triangle" of Soviet Europe, which tapers to a blunt point in mid-Asia. Because of Russia's immense distances it is not profitable to ship foodstuffs from the "triangle" to the far north and east. New settlements must therefore develop their own food supply to avoid long hauls. For example, a government decree obliged all communities to grow their own potatoes. River valleys in the far east were cleared to raise food for new industrial settlements. Experimental farms were set up even in the tundra to supply hunters and lumber camps. In the far north the sun does not set for about six weeks, and this continuous light makes it possible to raise crops in spite of the short season.

Wheat and sugar beets are the chief crops grown in Russia's black-earth belt Efforts have been made to push frost-resisting varieties of wheat north into the cold forest zone; but the chief crops of the north are still those that have long been grown in this cool climate—rye, oats, potatoes, and barley. Millet and sunflowers are cultivated in the dry steppes along the Volga. Rice and corn are grown in the Ukraine and north Caucasus. Orchards and grapevines flourish in the south of the fertile triangle, but in general Russia is poor in fruit. Russian horticulturists, however, have evolved some dwarf fruit trees that can be completely covered and thus survive the frosty winters in the north. Citrus fruits, tea, and tung trees are raised on the tropical rain-drenched Black Sea coast of Georgia in the Transcaucasus.

The chief industrial crop is cotton. It flourishes in the warm irrigated valleys of Turkestan, particularly in the Vale of Fergana, one of the most densely peopled regions in the Soviet Union. A drought-resisting variety is grown on unirrigated plantations in the southern Ukraine near the Black Sea. Seed flax and the long-fibered variety used in making linen are raised in the lake country south of Leningrad, the greatest flax-producing region of the world. Hemp and rami are also raised extensively. More than a million acres are planted to *kok-saghyz*, a rubber-bearing plant which Soviet scientists discovered growing wild on the slopes of the Tien Shan.

DIVERSE PRODUCTS OF A VAST COUNTRY

In the laboratory of a collective farm in the Crimean peninsula (top picture), women weigh test samples of the cotton crop. On the cold tundra of Siberia (middle), thousands of miles from the almost tropical Crimea, a plane lands to bring supplies to the trappers and carry off valuable furs. Dairy cattle (bottom) graze on the meadows of a state farm south of Moscow, where the forest merges with the grassy steppes.

Stock Raising, Dairying, and Fisheries

Great herds of beef cattle and sheep and droves of horses and camels graze on the vast plains of the Kazak Republic in Soviet Asia. Mountaineers take

their sheep and goats to alpine pastures in summer, returning to the lowlands in autumn for shearing and slaughtering. In the far north nomad reindeer breeders pasture their domesticated herds on mosses and lichens. Most of Russia's butter comes from dairy farms on the steppes of Siberia and the meadows of the lake country near the Baltic Sea.

The rivers and seas abound in countless varieties of fish. The Caspian Sea is the chief source of caviar (the roe of the sturgeon) which is exported to markets all over the world (*see* Caspian Sea). Salmon are caught in the rivers of the far eastern regions and crabs on the coast of Kamchatka. The Arctic fisheries also yield a rich catch.

Timber and Furs

Russia exports more lumber than any other country in the world; yet the amount of timber cut each year is less than the annual growth. The great forest reserve of Siberia has hardly been touched because of transportation difficulties, but new lumber camps have sprung up with the opening of a sea route through the Arctic Ocean. The forests of Soviet Europe are easily accessible. Lumber is rafted down the Volga and the Dnieper to southern Russia, or north to the Arctic for export. Archangel, at the mouth of the Dvina River on the Arctic, is Russia's chief lumber port.

Some of the world's most beautiful furs—fox, ermine, and sable—come from Russia's great forests. Pelts of 30 million squirrels are exported in a single year. The American muskrat is being acclimatized, and the government is also making efforts to introduce the American mink.

Immense Mineral Resources

Russia possesses deposits of practically every useful mineral, and stands among the first countries in the world in her reserves of coal, oil, and iron.

Most of the anthracite and coking coal come from the Donets River basin (*Donbas*) in the southeast Ukraine. Another huge deposit (the Kuznets coal basin) has been developed in Siberia, in the foothills of the Altai Mountains. Third in importance in coking coal is the Karaganda basin, north of Lake Balkhash, in the Kazak Republic. Other coal deposits occur in eastern Siberia, and poorer grades are mined in the Urals and the region around Moscow. Peat is plentiful in the north and is used extensively for heating and to furnish electricity.

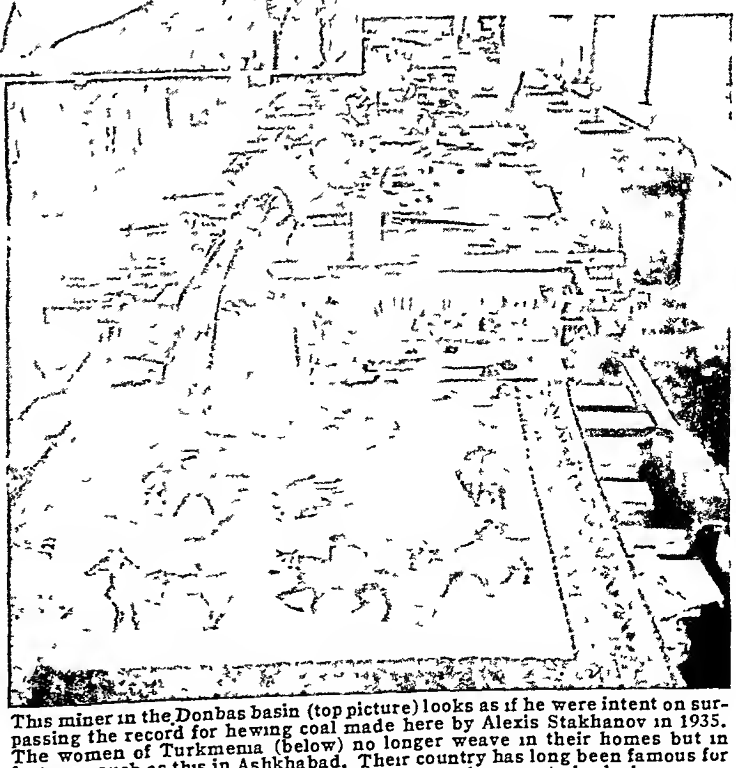
The southeast Ukraine, the "Soviet Pennsylvania," stands first in Russia for its production of iron ore as well as for coal. The famous Krivoi Rog iron district accounts for more than half of Russia's iron. The Kerch peninsula in the Crimea also has important iron mines, and the twin-peaked Magnet Mountain in the Urals is 60 per cent pure iron. Iron is found also in eastern Siberia.

The world's greatest deposits of manganese ores—valuable material for strengthening steel—are found in the eastern Ukraine and in the Republic of Georgia in the Transcaucasus. Other deposits occur in the Urals and in western Siberia.

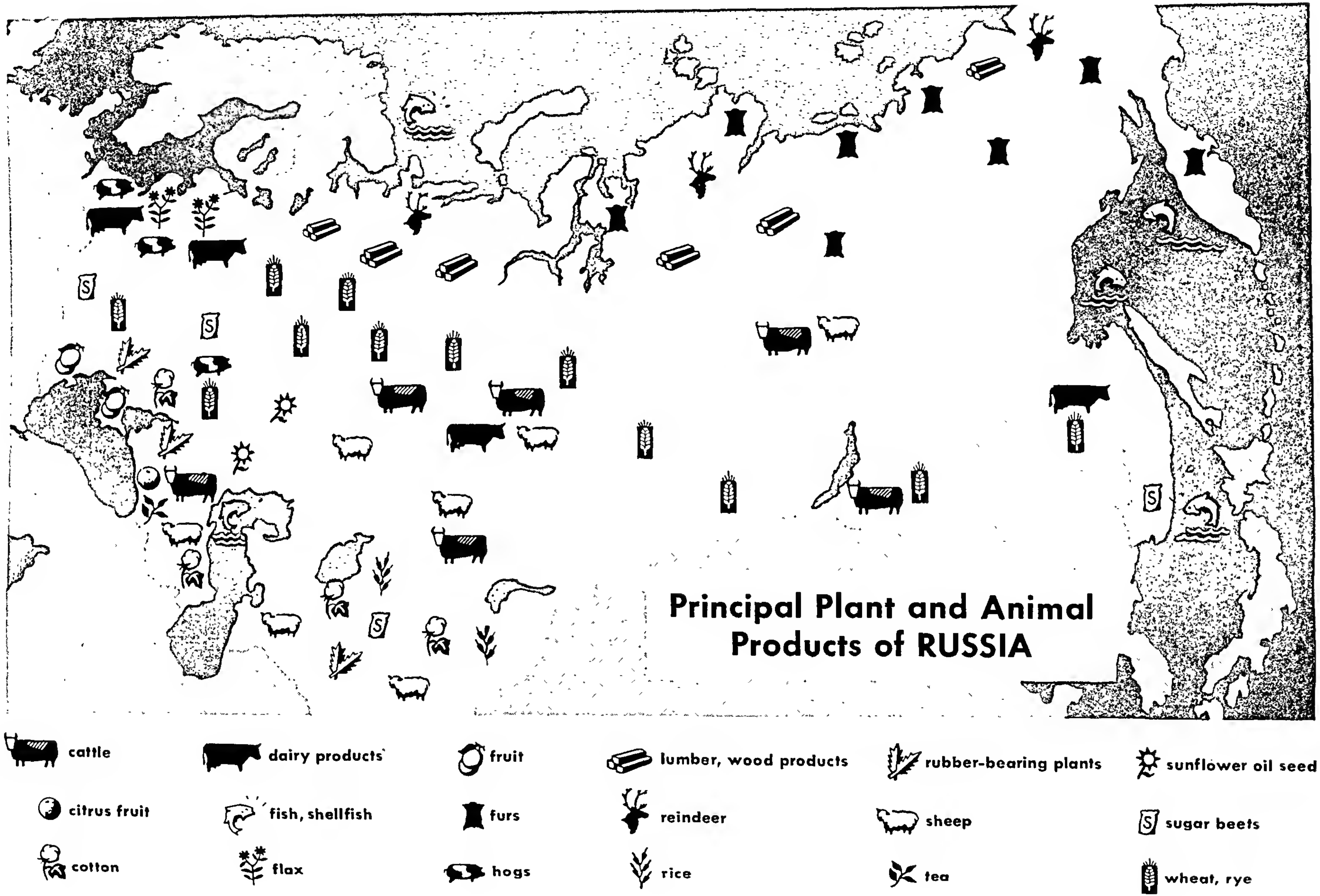
Gold is mined principally in Siberia, but the rich Urals also have gold as well as platinum deposits. Practically inexhaustible supplies of apatite—used for fertilizer and in industry—occur in the Kola Peninsula in the extreme northwest. Salt is mined in the Ukraine and other places and potassium salts in the Urals. Russia also has valuable deposits of copper, zinc, lead, bauxite (the raw material for aluminum), nickel, asbestos, tin, magnesium, tungsten, and molybdenum.

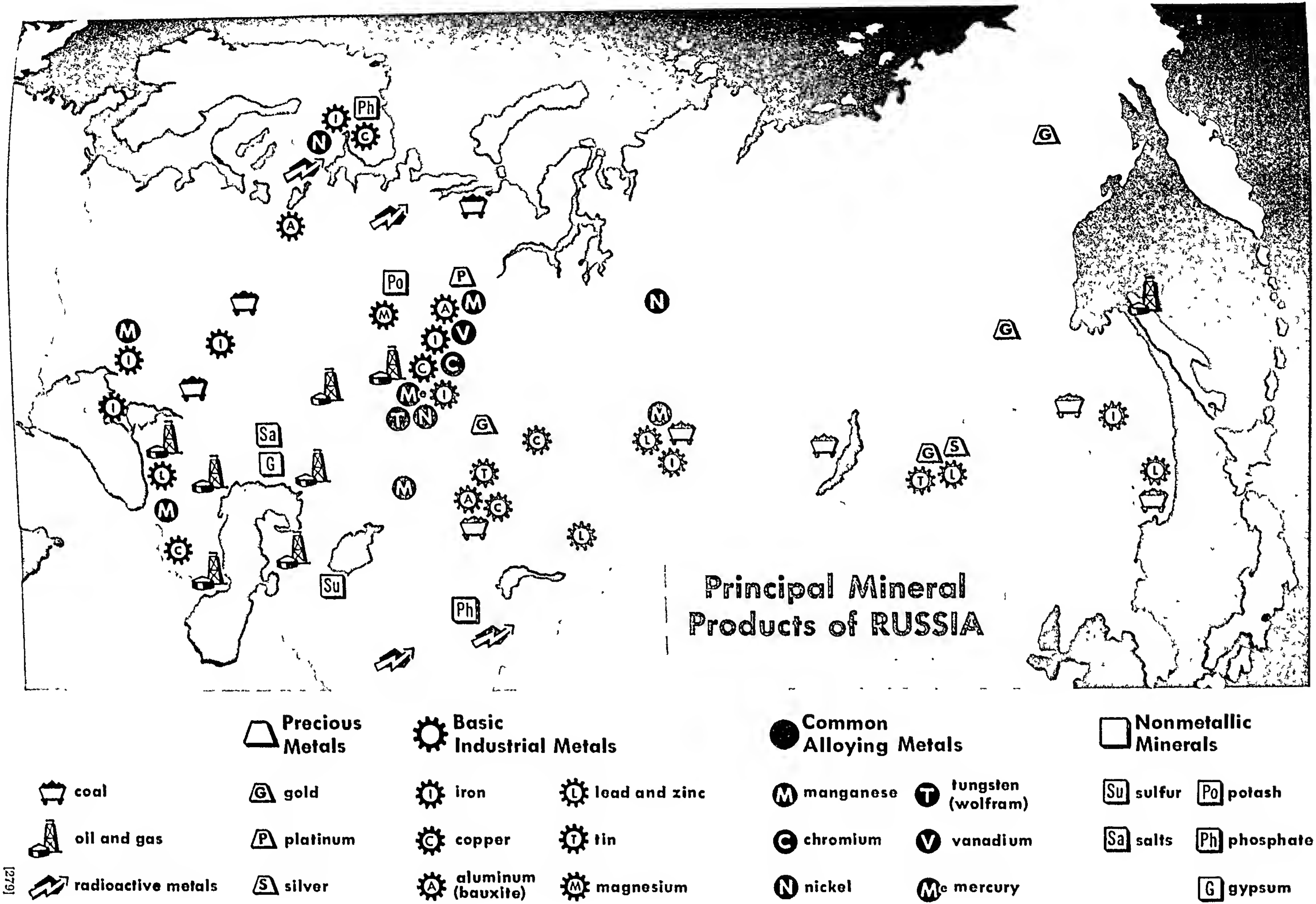
Russia's oil reserves are among the largest in the world. Most of her output comes from the famous Baku fields in the Transcaucasus Other large deposits occur in the north Cau-

MECHANIZED MINING AND HAND WEAVING



This miner in the Donbas basin (top picture) looks as if he were intent on surpassing the record for hewing coal made here by Alexis Stakhanov in 1935. The women of Turkmenia (below) no longer weave in their homes but in factories such as this in Ashkhabad. Their country has long been famous for its beautiful carpets, deep red in color and exquisite in design.


Principal Plant and Animal Products of RUSSIA
cattle
dairy products
fruit
lumber, wood products
rubber-bearing plants
sunflower oil seed
citrus fruit
fish, shellfish
furs
reindeer
sheep
sugar beets
cotton
flax
hogs
rice
tea
wheat, rye


Principal Mineral
Products of RUSSIA
Precious Metals
Basic Industrial Metals
Common Alloying Metals
Nonmetallic Minerals
coal
oil and gas
radioactive metals
gold
platinum
silver
iron
copper
aluminum (bauxite)
lead and zinc
tin
magnesium
manganese
chromium
nickel
tungsten (wolfram)
vanadium
mercury
sulfur
salts
potash
phosphate
gypsum

casus (at Grozny and Maikop), on the north shore of the Caspian Sea (the Emba fields), in the Urals, and along the Volga. In the far east the island of Sakhalin is the chief producing area.

Production by Five-Year Plans

In 1928 ("the year of great change") Stalin started a gigantic experiment to achieve Russia's industrial revolution. All productive activity in the Soviet Union was to be prescribed in every detail by one central planning authority in Moscow. The 1928 program and others that followed were called "five-year plans." The government usually announced, however, that it expected the people to fulfill (or "overfulfill") the plan in four years.

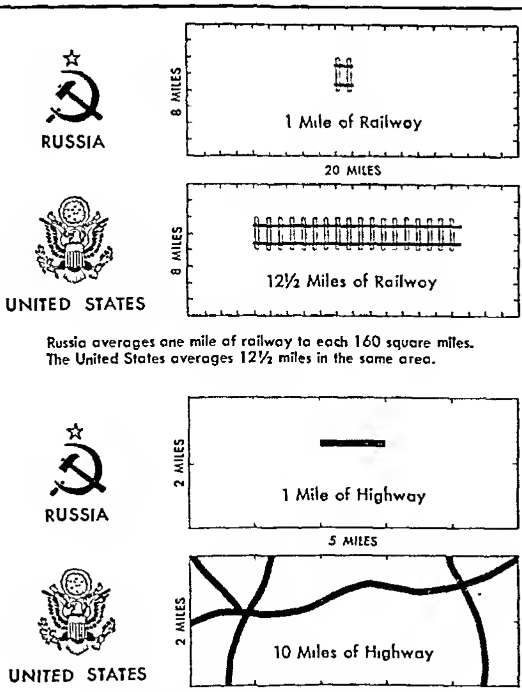
All the plans have aimed primarily at building up heavy industry and providing armament. By prodigious efforts, the Soviet Union raised its output of coal, iron, steel, and oil until it made itself the second industrial power in the world. Yet it still lags far behind the United States in basic industrial materials. And it has proved unable to provide adequate housing and consumers' goods for the people.

Chief Centers of Soviet Industry

The main project of the first five-year plan was the construction of the giant Dnieper Dam to supply electricity to plants in the Ukraine (*see* Ukraine). Farther east, at Stalingrad, on the lower Volga River, American engineers put up a huge plant with a yearly capacity of 50,000 tractors (*see* Stalingrad).

The second and third five-year plans (launched in 1933 and 1936) called for building up industry in Soviet Asia. The Ural Mountains have iron but no

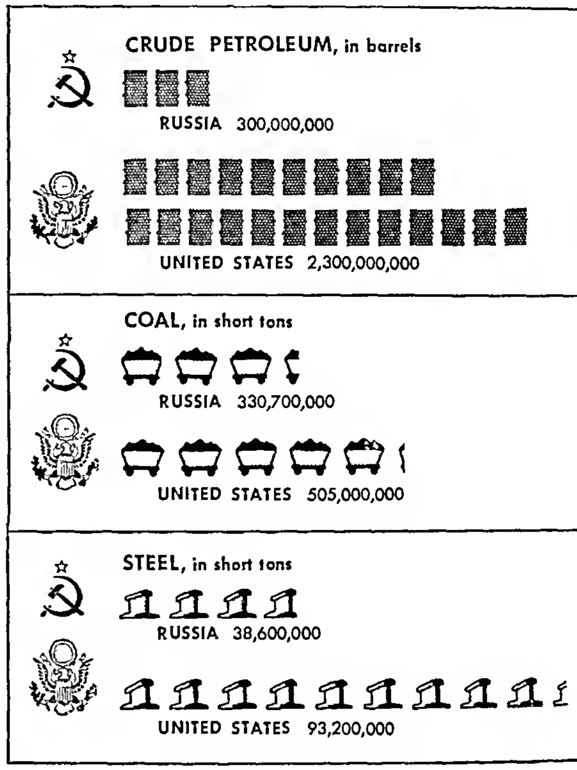
RAILWAY AND HIGHWAY MILEAGE COMPARED



Russia averages one mile of railway to each 160 square miles. The United States averages 12½ miles in the same area.

Russia averages one mile of highway to each ten square miles. The United States averages ten miles in the same area.

MINERAL PRODUCTION—A COMPARISON



Russia's production figures are taken from Premier Malenkov's speech of August 9, 1953.

coking coal. A railway was built to the Kuznets coal basin, 1,200 miles east, and trains carry iron east and coal west. Stalinsk, in the Kuznets basin also became an iron and steel center. The centers of heavy industry in the Urals are Magnitogorsk (named for Magnet Mountain), Nizhni Tagil, and Sverdlovsk—all on the eastern slope of the Urals.

In the far east Young Communists built a new city for shipbuilding and machine manufacture at the head of navigation on the Amur River. It was called Komsomolsk after its founders. An attempt to found a Jewish colony in Birobidzhan on the Amur River, in Siberia, did not succeed.

The fourth and fifth five-year plans again emphasized armaments. Priority was given to atomic fission plants in central Asia. In 1952 it was estimated that even if the goals of the fifth five-year plan (begun in 1951) were attained, the Soviet Union would produce in 1955 only about half as much in industrial goods as did the United States in 1951. Since the Soviet population is much greater than that of the United States, its per capita production would be only about one third as great.

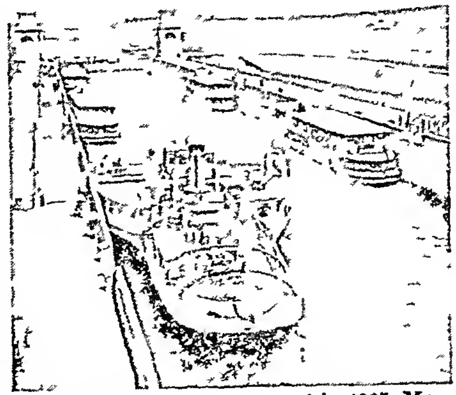
Transportation and Communication

TRANSPORTATION in Russia is utterly inadequate for a modern industrial nation. Dirt lanes wander over the countryside. After heavy rains they are impassable even for oxcarts. Rivers provide many thousands of miles of cheap transportation; but in midsummer the water is too low for navigation in

many places. In winter the frozen surfaces serve only as highways for sledges. Most of the roads and railways lie in the western part of Soviet Europe. Yet even here an American who is permitted to enter Russia is struck by the lack of motion. Even on the edge of Moscow he sees few trains and almost never a car or truck.

The Soviet government has added little to Russia's railway mileage except in the east. There the single-tracked Trans-Siberian railway was double-tracked, and from it a line was constructed south to the cotton lands of Turkestan—the Turksib (Turkestan-Siberia) Railway. The White Sea-Baltic Canal (one of the first projects for which forced labor was used) was constructed in the early days of the Soviet régime. The Moscow-Volga Canal was completed in 1937. To tap the resources of northern Siberia, ships push through the Arctic in summer, escorted by icebreakers.

THE MOSCOW-VOLGA CANAL



With the opening of this canal in 1937, Moscow became an inland port. It connects the Moscow River with the Volga. Other canals link the headwaters of the Volga with the Baltic Sea. Water for the Moscow-Volga Canal has to be pumped 125 feet uphill.

Communications are as inadequate as transport. Few Russians have telephones; and they work so poorly they are of little use except for making appointments. Mails and telegrams are very slow. Since every important decision must be referred to Moscow, the poor communications system causes a serious loss of time.

Foreign Trade Is Small

Foreign trade is a government monopoly. Machinery, textiles, and raw materials for textiles form the chief imports. The chief exports are timber, minerals, furs, and canned fish. In proportion to its population and production, Russia has the smallest foreign trade in the world.

Inside Russia there is no trade at all except in black markets and in the open-air markets where peasants sell what they can spare from their gardens. Each peasant must go to market with his own produce. He is forbidden to ask a neighbor to sell for him.

The Government—A Communist Dictatorship

THE Soviet Union adopted its first constitution in 1924. It adopted its present constitution in 1936 and amended it in 1947. The constitution declares that "The Union of Soviet Socialist Republics is a socialist state of workers and peasants." The constitution also says that life in the Soviet is based on the principle of socialism: "From each according to his ability, to each according to his work." This principle differs from an earlier Communist theory which maintained that people should be paid according to needs rather than deeds.

Land and all industry are declared to be the property of the state—"that is, belong to the whole people." Most of the dwellings also belong to the state. The citizen's private property is limited to his furniture, clothing, and income from work.

The constitution decrees self-government for this socialist state. It declares, "In the U.S.S.R. all power belongs to the working people of town and country as represented by the Soviets of Working People's Deputies. . . . The highest organ of state authority of the U.S.S.R. is the Supreme Soviet of the U.S.S.R."

Government Actually a Dictatorship

THUS in theory the government of the U.S.S.R. is parliamentary, because the Supreme Soviet supposedly makes the laws. Actually it does not. The real power of government is held by leaders of the Communist party. They draw up every law and every government policy, and the Supreme Soviet merely approves the measures unanimously. Thus the government of the U.S.S.R. is not parliamentary and not representative. Instead, it is a dictatorship.

Unlike countries with representative government, Soviet Russia has only one political party—the Communist party, and the membership is kept small. The Soviet constitution declares that anyone 18 years of age or older may vote and be nominated for public office. In reality, a nominee must be a Communist or approved by the Communist party. Russians are virtually forced to vote. Usually, however, only one name appears on the ballot for each office.

Nature of the Communist Party

The Communist party is not like the major political parties in the United States or other democratic nations. The Communist party is more like a secret society. Members live under stern discipline. They must put party interests ahead of their personal interests.

At the head of the Communist party is the secretary-general. Russians call him *vozhd* (leader). He is the dictator of Soviet Russia. The first dictator of the U.S.S.R. was Nikolai Lenin. He was succeeded by Joseph Stalin, who seized power in 1925 (*see* Lenin; Stalin; Trotzky).

Members of the party must believe without question the socialist doctrines of Karl Marx as interpreted by the dictator. Party membership is kept small to insure discipline. In 1950 the membership reached a record high of some 7,000,000. Yet this represented little more than 3 per cent of the total population of the U.S.S.R. Ruthless purges reduce the membership from time to time.

How the Party Selects New Members

The party admits new members only after careful screening. All applicants come from the League of

Young Communists (Komsomols). Each applicant must be sponsored by three Communist party members. The party then checks the applicant's character and record. If accepted, the applicant enters a political school to study Marxian doctrine. His conduct is always under scrutiny. After an examination, he receives the red booklet of party membership.

His life is then at the command of the Communist party. He must go where he is ordered and do what he is told, regardless of danger. Some members are sent to foreign lands to work for Communism there. Every member must follow "the party line." That is, they must follow the plans laid down by the secretary-general. Members suspected of differing from the party line are purged from the party. Many former members are in Russia's forced-labor camps.

The Powerful Politburo

Until 1952 the highest organization in the Communist party was the *Politburo.* It was headed by the secretary-general of the party, Joseph Stalin. In 1952 it was superseded by a new body called a *Presidium,* which is described later in this article.

The Politburo was not a branch of the formal government of the U.S.S.R.; but, as the highest party organ, it controlled the government and the life of every Russian. It dictated Soviet foreign policy, drew up all the laws, prescribed the five-year plans, and controlled the armed forces and secret police. The Supreme Soviet met only to approve the decrees of the Politburo. The Politburo also directed the work of Communist parties in all foreign countries.

The Central Committee and the Orgburo

The chief administrative arm of the Politburo was the Central Committee of the All-Union Communist party. The committee had about 70 members. The *Orgburo* (organization bureau) controlled local party units, or "cells." These cells still operate throughout the U.S.S.R. in every village council (soviet), in every office, school, factory, and labor union, and in the armed forces. The local units send delegates to the All-Union Party Congress held in Moscow.

The Secret Political Police

The Politburo kept its hold on the Russian people by a secret force of political police. Few people dared to criticize the Politburo or the Communist party, because police spies are everywhere. They are in every apartment house and collective farm and factory, in every educational and scientific group, and in the armed forces. Every Russian, even an official, lives in fear of being rushed by police spies to a secret trial and sentenced to a labor camp. Because police terror is used to maintain control, the U.S.S.R. is sometimes called a *police state.*

The political police has had many names. The Bolsheviks revived the Czar's political police (*Okhrana*) in 1917 only a few months after they seized power. They called the new organization *Cheka.* In 1923 they changed the name to OGPU (Gay-Pay-Oo); in 1934 to NKVD. In 1946 they split the force into two parts: the MGB, which operates chiefly abroad, and the MVD, which polices Russia and operates the forced-labor camps. In addition to plain-clothes operatives, the MVD has about 20 divisions of uniformed troops, armed with artillery, bombers, and fighter planes.

The Comintern and the Cominform

Russian Communists believe that all countries with other forms of government are enemies of Soviet Russia and of the working people. They think the Soviet state will not be secure until every country in the world is communized. To achieve this goal they maintain Communist parties wherever they can.

In 1919 Moscow set up the *Comintern* (Communist International) to direct the Communist parties outside Russia. During the second World War Russia was allied with Western nations and officially dissolved the Comintern as a concession to foreign opinion (1943). But the Politburo continued to direct the activities of the Communist parties in other lands and to demand strict adherence to the party line. Schools in Moscow continued to train groups from all over the world and then send them home to promote Communist policies.

In 1947 the Politburo openly revived the Comintern under a new name, the *Cominform* (Communist Information Bureau). The Cominform controls Russia's satellite governments in eastern Europe. It also directs Communist parties outside the Russian sphere. Activities of these parties include strikes, sabotage, and even armed insurrection. These measures aim to weaken established governments and make it possible for Communists to seize power.

Party Reorganized in 1952

In 1952, at the first All-Union Party Congress since 1939, a new body, a *Presidium,* was created to combine the functions of the former Politburo and Orgburo. The Presidium consists of 25 members. The Central Committee was increased to 125.

Features of the Formal Government

MEMBERS of the Supreme Soviet are elected by direct popular vote for four years. The Supreme Soviet consists of two chambers—the *Soviet of the Union,* which represents all the people, and the *Soviet of Nationalities,* which represents the various Union republics and national groups. They meet only a few days twice a year. Theoretically they meet to draw up laws, but actually they merely unanimously consent to decrees of the Communist leaders.

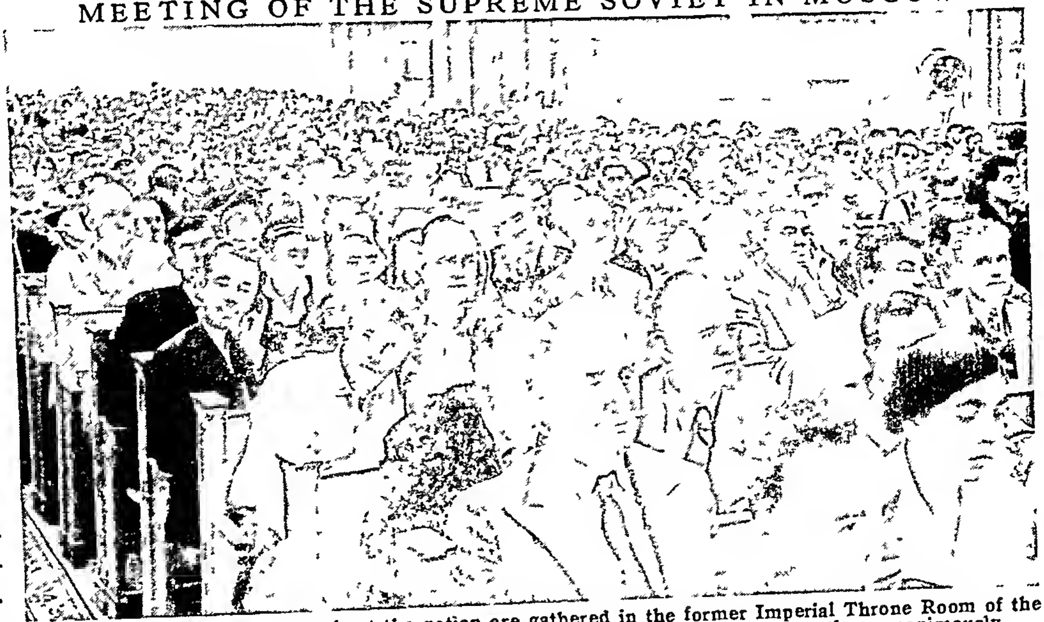
A standing committee, the *Presidium of the Supreme Soviet,* meets continuously. It approves the party's Presidium decisions between sessions of the Supreme Soviet. The president of the Supreme Soviet Presidium (often incorrectly called the president of the U.S.S.R.) signs all laws, but this is a mere formality. He has no presidential power as in a republic.

The cabinet of the U.S.S.R. is the *Council of Ministers.* Until 1946 it was called the Council of Peoples' Commissars. The Council includes ministers of foreign affairs, defense, and education. It includes also the chairman of the State Planning Commission (called *Gosplan*), and the heads of all industries. The Council issues orders that have the force of law,

and supervises their enforcement.

Each of the 16 Union republics has its own supreme soviet, its own council of ministers, and its own constitution, similar to those of the U.S.S.R. The supreme soviets of the republics "approve the national economic plan." The Council of Ministers of the U.S.S.R. has the right "to annul orders and instructions" given by councils of the republics.

MEETING OF THE SUPREME SOVIET IN MOSCOW



Delegates from soviets throughout the nation are gathered in the former Imperial Throne Room of the Kremlin. They are listening to the central government's plans and will approve them unanimously.

The Union constitution expressly states that the republics have the right "freely to secede from the U.S.S.R."; but any republic that tried to do so would certainly bring on civil war. In 1944 the U.S.S.R. constitution was amended to allow Union republics to have their own armies (although this was never actually put into force) and their own diplomatic representatives in foreign countries. These amendments made it possible for the Soviet Union to obtain membership in the United Nations for the Ukrainian S.S.R. and the Byelorussian S.S.R.

The Rights and Duties of Citizens

Among the "rights of citizens" the constitution lists rest and leisure, the right to work, the right to maintenance in sickness and old age, and the right to education. Women are accorded equal rights with men. The advocacy of "racial or national exclusiveness" is punishable by law. Work is "a duty and a matter of honor for every able-bodied citizen," and "he who does not work, neither shall he eat." Universal military service "is law."

Freedom of religious worship is "recognized" but so is freedom of antireligious propaganda. The following freedoms are listed: freedom of speech, freedom of the press, freedom of assembly, freedom of street processions and demonstrations. These freedoms are "ensured" not by the courts but by "placing at the disposal of the working people . . . printing presses, stocks of paper, public buildings, streets. . . ." Actually, of course, presses, paper, buildings, and streets belong to the government and can be used only as it directs. The constitution also specifies just what organizations citizens may join: "trade-unions, youth organizations, sport and defense organizations, cultural, technical, and scientific societies," and "the Communist party of the Soviet Union (Bolsheviks), which . . . is the leading core of all organizations of the working people."

The Problem of Selecting a Dictator

A significant difference exists between the constitution of the United States and the constitution of the U.S.S.R. The United States constitution provides carefully for the election of a president, his duties and powers, and for his successor. The Soviet constitution says nothing about the real head of the state, the dictator. He stands above the constitution and the laws and is accountable to no one.

The dictator's power rests upon his ability to control the party members and high government officials. He must also keep a firm hand on the secret police to insure that they will break up any revolutionary movement. When he dies or retires, presumably the Presidium appoints his successor. The smoothness of the change depends upon party discipline and the new leader's power to command obedience.

The Rise and Growth of the Russian Nation

IN THE early centuries of the Christian Era the Slavs began to spread out from their homeland north of the Carpathian Mountains—the region later known as Poland (*see* Slavs). Some tribes moved east into Russia. In canoes made of hollowed-out tree trunks they paddled along the rivers, settling in the dense forests to the north of the grassy steppes. They lived chiefly by hunting and fishing, but sometimes they burned over a patch of woodland and sowed some grain. They were pagans who swore by their great god of thunder and by lesser gods. They burned their dead on high funeral pyres—feasting while they did so—and then put the ashes into urns placed on posts by the roadsides.

The Slavs found scattered Finnish tribes living in the forests, and they forced these people out to the

far north. South of the forest spread the great open steppes. Into these rich grasslands wandering Asiatic herdsmen were continually pouring in from the east. They rode tough wiry horses, were well armed, cruel, and hardy. The Slavs, who fought on foot, found they were no match for these mounted warriors on the open plains, and stayed in their woods. But often the steppe people rode up the forest valleys, burned the little villages, and carried off the Slavs into slavery. It was to take the Slavs a thousand years to establish their control over the "wild fields" to the south.

In the third century the Goths invaded Russia from Sweden, and in the fourth century the terrible Hun cavalry poured in from Asia (*see* Goths; Huns). When these barbarian invasions had spent their strength the Slavs appeared even more numerous than before. By the year 600 their scattered hamlets of wooden houses and mud huts were strung out along all the rivers of western Russia. Important trading settlements had grown up—Novgorod, in the north, and Kiev, the "mother of Russian cities," on the lower Dnieper River.

The Dnieper Becomes a Great Trade Route

To the south of the Black Sea lay the Eastern Roman Empire with its fabulously rich capital, Byzantium (*see* Byzantine Empire). In the Scandinavian peninsula lived the Northmen, sea rovers and pirates, who sailed far in their swift ships and discovered the wealthy Greek lands (*see* Northmen). The Northmen could not hope to attack Byzantium from the Mediterranean because their ships could be easily stopped at the narrow Dardanelles. So they decided to trade with the Greeks instead. The shortest and safest way to Byzantium lay across the land of the eastern Slavs. From the Baltic Sea they could push inland through lakes and rivers. At Novgorod they could haul their small boats overland on wooden wheels to the headwaters of the Dnieper. Once on this great river the way was easy to the Black Sea and Byzantium.

The Slavs called the Northmen "Varangians" and the Dnieper came to be known as "the great trade route from the Varangians to the Greeks." Commerce grew and the Slavs shared in the prosperity. Their small craft carried downstream wax and honey, fur and slaves. In return the Slav chieftains received from Byzantium tools and weapons, clothes and wine.

Rurik Founds a Long Dynasty

In the 9th century the Slavs were still living in small family groups under their tribal chieftains. They had no unified government and warred constantly among themselves. They had great respect for the Varangians, who protected their fleets against the fierce nomad tribes in the steppes. And according to Nestor, a monk of Kiev who lived about 1100, the people of Novgorod decided to send an invitation to the *Rus*, a Varangian tribe, and ask for a leader to come and rule over them. Nestor wrote:

> There was no justice among them, and clan rose against clan, and there was internal strife between them, and they began to make war upon each other. And they said to each other: "Let us seek for a prince who can reign over us and judge what is right." And they went over the sea to the Varangians, to *Rus*, for so were these Varangians called: they were called *Rus* . . . "Our land is large and rich," they said, "but there is no order in it: come ye and reign over us."

Rurik, a chieftain of the Rus, accepted that offer, came down to Novgorod, and became the first of a dynasty that was to lead Russia for more than seven centuries. Russians date the beginning of their empire from his arrival, about the year 862.

When Rurik died, a relative, Oleg, became grand duke of Novgorod. He sailed 1,500 miles down the river, added Kiev to his domains, and made it his capital. Olga who succeeded her husband, Igor, rode with her armies to battle the nomads on the steppes; and legend says she became a Christian. Her son, Sviatoslov, who followed her, dreamed of a great nation of united Slavs, and spread the rule of Kiev from the Danube to the Volga.

The Rise and Fall of Kiev Russia

As the civilizing influence of Byzantium filtered into Russia the old pagan religion of the Slavs began to crumble. In 988 Sviatoslov's son, Vladimir, embraced Christianity and ordered the old wooden idols on the river banks tossed into the water. Greek missionaries moved in, bringing to the Russians not only their religion but Byzantine art and architecture and an alphabet in which the Slavs could write their native language.

Under Vladimir's son, Yaroslav the Wise, Kiev became a rich and beautiful city. His palace was a fair-sized wooden house with elaborately carved ornaments over its doors and windows; but the great cathedral of St. Sophia he had built of stone, rearing ten golden cupolas to the sky. As in other Russian cities, the ducal palaces and churches formed a *kremlin* in the center of the city which was protected by walls and fortified towers.

After Yaroslav's death Kiev began to decline. The Volga River was beginning to rival the Dnieper as a trade route; and in 1147 a new city, Moscow, appears for the first time in the records. The lands that Yaroslav had united fell apart; and when they were again brought under one rule it was too late to stave off a great catastrophe.

The Darkest Period in Russian History

The savage hordes of Genghis Khan and Tamerlane were coming. The Golden Horde! These Mongolian Tatars from the fringes of the Gobi Desert were as fearless, tough, and merciless as the swords with which they slashed. They had dark countenances, short legs, and broad chests. They drank the blood of their cattle and horses. They had conquered China. In 1237 they swarmed into the land in countless thousands and a terrible battle was fought by the Sea of Azov. But there was no stopping the ruthless warriors of the Golden Horde.

After their first victory the Tatars were content to rest for a while. The territory they had taken lay between the Black Sea and the river Don. Here they formed their kingdom with the capital at Sarai, on a tributary of the lower Volga. Later they spread over practically all of Russia and levied tribute

upon its people. Oriental customs and ways of thought became ingrained in the Russians, separating them more and more from the peoples of the Western world. For more than 250 years the country suffered under Tatar domination (*see* Mongols; Tatars).

Russia Rises Again, Led by Moscow

Proud Byzantium had fallen to the Turks. But its church continued strong in Russia, reminding the people they were all one. The prestige of Moscow grew, and its grand dukes (descendants of a branch of Rurik's line) came to be looked on by the people as the leaders of all Russians and the protectors of their church (*see* Moscow).

The Tatars, weakened by internal discord and wars, were finally left in control only of the lower Volga Valley. From the beginning of his reign Ivan the Great, Grand Duke of Muscovy from 1462 to 1505, refused to pay tribute to them. In 1480 the Tatars sent an army against him. Ivan massed a great force and for weeks the two armies looked at each other across a narrow river. Then the water began to freeze over and the Tatars prudently withdrew without a battle. Ivan added Novgorod to his domains and spread Moscow's rule to the Arctic (*see* Ivan III).

Ivan the Terrible, First of the Czars

Ivan IV, called "the Terrible" because of his savage cruelty, ruled Muscovy from 1533 to 1584 (*see* Ivan IV). Not content with the title of Grand Duke, he had himself crowned Czar, the Russian word for Caesar, which the Russians had used for the emperors of Byzantium. Henceforth Russia's sovereigns ruled "by the grace of God," as absolute monarchs, responsible to the Almighty alone. Ivan spread Moscow's rule into Siberia and south to the Caspian Sea, making the Volga for the first time a wholly Russian river. But the West proved too strong for his armies. Kiev still lay outside Moscow's domains, ruled by the powerful Polish-Lithuanian kingdom.

Ivan the Terrible killed one of his sons, and the youngest, Dmitri, died at the age of nine. The only remaining son was Theodore the Meek, who, Ivan said, was more fitted to be a bellringer in a convent than a czar. When Czar Theodore died childless in 1598 the long line of the House of Rurik came to an end.

"The Time of Troubles"

Boris Godunov, whose name has been immortalized in song and story, was elected to succeed Theodore. A strong and prudent ruler, he consolidated Russia's territorial gains and even sent a dozen young men to Europe to learn Western ways—but none returned. Soon after he came to power, drought and famine followed by plague killed half a million people in Muscovy. Many peasants abandoned their villages and the land reverted to waste. Godunov thereupon forbade any peasant to leave the estate on which he was born, thus binding him to the soil. This was the beginning of serfdom in Russia.

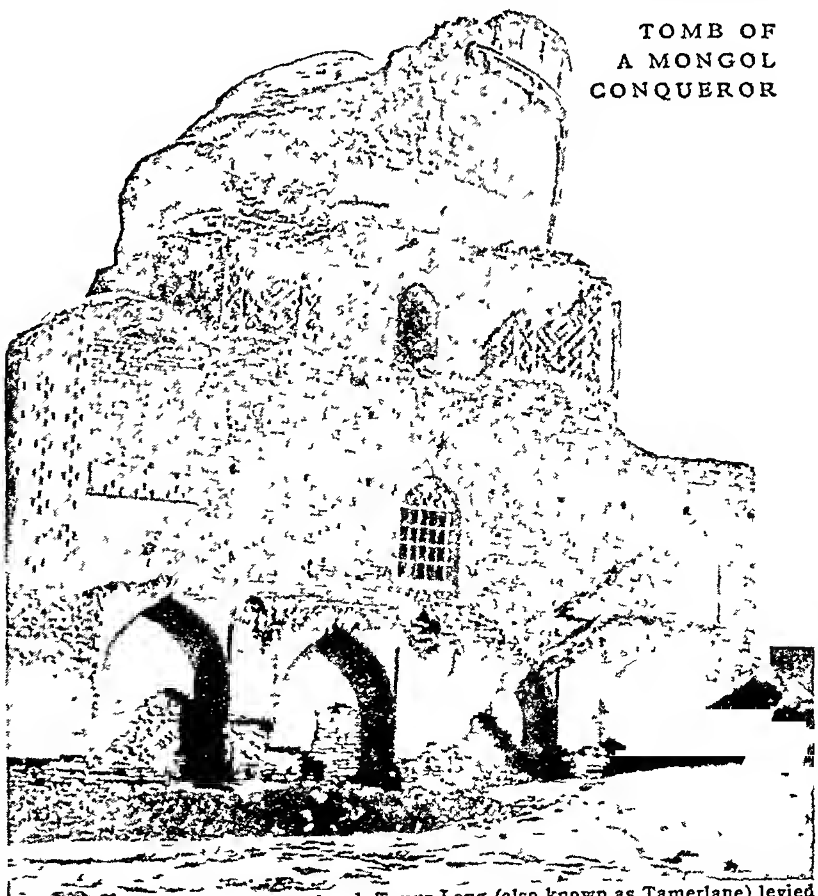
Godunov died in 1605, and the son who succeeded him reigned only a few months before being foully murdered. The Poles then brought forward the "False Dmitri," a young man who claimed to be the youngest son of Ivan the Terrible. Overjoyed at this resurrection of the House of Rurik, the Muscovites promptly crowned him czar. They soon discovered, however, that he was an impostor, and they rose and killed him. New "sons" of Ivan appeared with claims to the throne. Divided by civil wars, and raided by Cossacks from the south, Moscow opened its gates when a Polish army appeared before them in 1610, and accepted the son of the Polish king as czar.

After a time Russian guerrilla forces were gathered together from the countryside. They fought their way through the barricades of Moscow, stormed the Kremlin, and ousted the Poles. But Moscow was ruined.

First of the Long Line of Romanovs

When order had been partially restored an assembly met in 1613 and offered the crown to a young nobleman (*boyar*), Michael Romanov. Thus began the long

TOMB OF A MONGOL CONQUEROR



From his great capital at Samarkand, Timur Leng (also known as Tamerlane) levied tribute on the Russians. His tomb has suffered from time and earthquakes; but the tinted tiles are still marvelously beautiful.

line of the Romanovs, which was to rule Russia for 300 years until the Revolution of 1917.

A period of slow reconstruction set in. Incessant wars had drained Russia of its resources. Since the fall of the Byzantine Empire to the Turks, Russia had been out of touch with European civilization. The Russians had no literature except their old folklore, only primitive arithmetic, and no idea of science. Women were practically excluded from social life. Great reforms would be needed before this semioriental country could expect to hold its huge territory against the strong nations rising in the west. Then the towering figure of Peter the Great ascended the throne and shook Russia out of its long sleep.

Reforms of Peter the Great and Catherine

With the reign of Peter the Great (1689–1725) the modern period of Russian history may be said to begin (*see* Peter the Great). He was a man of unusual ability and iron will. He wanted his country to be more European—that is, more cultured and developed. He tried to accomplish this result by force of arms and compulsion. Through long and difficult wars, at terrible loss of life and property, he managed to wrest from Sweden the Baltic Sea area, the outlet to the great Russian plain on which his empire rested. Through violent changes, which tended to demoralize the people, he succeeded in modernizing his administrative machinery. He organized a modern army, and forced education upon his officers and the members of his court, many of whom could not even read. He required all men to register for service in his army, or for the building of canals and roads, for service in his new capital at St. Petersburg (Leningrad) or for work in the factories which he was the first to introduce into Russia. Those who would not or could not do any of these things were required to pay heavy taxes.

Peter died in 1725. His work survived almost a half-century of incompetent rulers, after which there came to the throne Catherine II, the Great (1762–1796), who took up again the task of reform. By 1800 Russia had become established as a modern state, and had taken the first steps in internal development, such as the spread of education, the establishment of means of communication, and the manifestation of some regard for the well-being of the people.

Reigns of Alexander I and Nicholas I

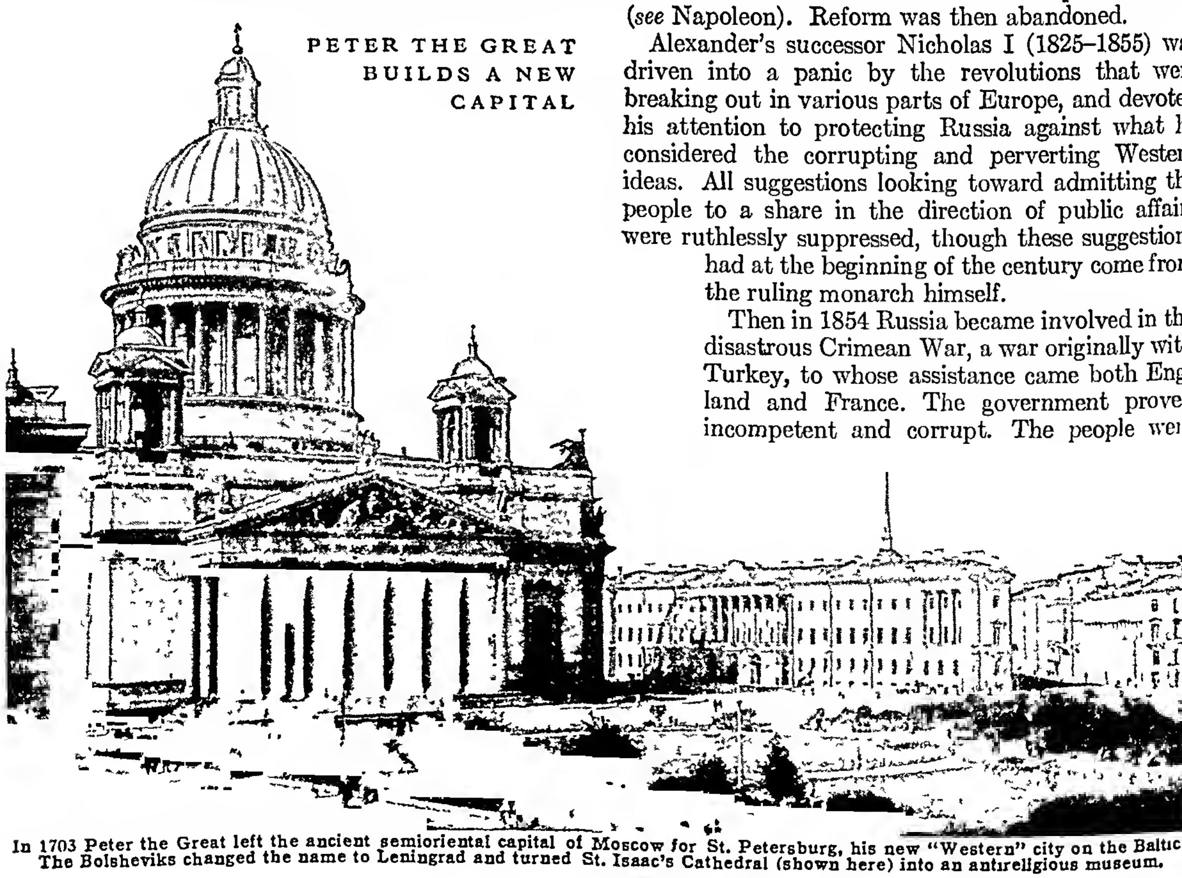
During the centuries of struggle the peasant serfs, who were the majority of the people in this agricultural country, had been burdened with so many taxes to the state, and payments of money and labor to their landlords, that their spirit was broken. The first task of internal reform was therefore to make their lot easier.

Alexander I (1801–1825) began his reign in a progressive spirit. Plans were drawn up for a representative assembly or *Duma* to propose new laws. He had already commenced to carry out his program when Russia became involved in the Napoleonic wars (*see* Napoleon). Reform was then abandoned.

Alexander's successor Nicholas I (1825–1855) was driven into a panic by the revolutions that were breaking out in various parts of Europe, and devoted his attention to protecting Russia against what he considered the corrupting and perverting Western ideas. All suggestions looking toward admitting the people to a share in the direction of public affairs were ruthlessly suppressed, though these suggestions had at the beginning of the century come from the ruling monarch himself.

Then in 1854 Russia became involved in the disastrous Crimean War, a war originally with Turkey, to whose assistance came both England and France. The government proved incompetent and corrupt. The people were

PETER THE GREAT BUILDS A NEW CAPITAL



In 1703 Peter the Great left the ancient semioriental capital of Moscow for St. Petersburg, his new "Western" city on the Baltic. The Bolsheviks changed the name to Leningrad and turned St. Isaac's Cathedral (shown here) into an antireligious museum.

angered by the continued burdens of war, and the peasant serfs rose against the landowners in many places and burned and pillaged estates. These and like disorders, which had been increasing in frequency for years past, assumed threatening proportions.

The Serfs Are at Last Emancipated

Before the war was over a new monarch, Alexander II (1855–1881) came to the throne. He brought the fighting to a conclusion as quickly as possible, and then announced that reform was to be the order of the day, and that it was to begin with the emancipation of the serfs. He frankly said that it would be better to have this measure carried out from above than to wait for it to be forced upon the government from below. Commissions were appointed to work out the details of the emancipation, and to prepare other liberal reforms, such as the introduction of elective local councils, a new and modern system of law courts, and larger freedom for the press.

The act of emancipation, issued in March 1861, gave liberty to some 40,000,000 serfs. It was to be a gradual emancipation, in order that both landlords and former serfs might have opportunity of readjustment. The lands assigned to the peasants were less than they had formerly occupied, and they were burdened with heavy redemption payments for them for many years; not until 1905 did these payments come to an end. But the act on the whole was liberal and just.

Other reforms followed, introducing the elective local councils (called Zemstvos) and establishing a modern system of law courts for the administration of justice. Thus three great steps were taken toward constitutional government and the protection of the Russian citizen from the arbitrary acts of an autocratic government.

Revolutionary Agitation Grows

But the long years of tyranny and lack of progress had produced discontent, particularly among younger persons who had been educated at the universities, of which there were now eight of large size in Russia. Largely under the influence of abstract theories developed in Germany and France, revolutionary agitation and organization developed rapidly. A small group of such revolutionaries tried to organize an uprising of the emancipated serfs. The isolated, suspicious, and uneducated peasants did not respond, and the attempt failed. But the government authorities were aroused, and the influence of those who were antagonistic to reform was strengthened.

When an attempt on the life of the czar was made by an individual, acting on his own account, these antireform leaders completely prevailed. At their persuasion Alexander II curtailed many of the reforms already started, and allowed others to be carried out only in form. Such repression bred more revolutionary sentiment, and soon the government was fully engaged in the suppression of disorder to the neglect of the deeper welfare of the people. The revolutionary movement culminated in the assassination of Alexander II in 1881 by a nitroglycerin bomb hurled at his carriage. He was succeeded by his son Alexander III, 1881–1894, who simply continued his father's policy.

The process of emancipation continued now under conditions that did not insure to the peasant even the limited rights that had been granted in 1861. The Zemstvos continued to develop, but too slowly to meet the needs of the people. The third of the great reforms, the organization of a just administration of the law, was practically abandoned in favor of a return to arbitrary police methods of government. The censorship of the press became more rigid than before. Revolutionary organizations were completely suppressed, but not revolutionary feeling. Discontent grew under persecution, and upon new and increasing grounds.

In 1894, upon the death of Alexander, Nicholas II (1894–1917) succeeded to the throne. Again the educated and progressive leaders hoped that the reform movement might be resumed, particularly as revolutionary activities had practically ceased. The new czar proved, however, to be a man of limited outlook, though possibly of good and kindly intentions. He believed implicitly in the divine origin of his autocratic power, and in its necessity for the welfare of his country. He definitely put an end to all thought of coöperation in reform by calling the petitions for very moderate changes "senseless dreams."

The First Duma Is Convened

In 1904 Russia and Japan went to war over a dispute respecting rights in the Far East (*see* Russo-Japanese War). The war was not popular in Russia; and when defeat came, largely because of the corruption and incompetence of the government, followed by a humiliating peace, the revolutionary movement began again. A factory laboring class, quite distinct from the peasants, had now arisen and it was organized for action by revolutionary leaders. Peasants sympathized and helped. Mutinies broke out in the army and fleet. In this emergency progressive manufacturers and landlords demanded measures of reform which would satisfy the just demands of workmen, peasants, and soldiers. After a general strike, supported by all classes in the community, and continuing for a week, Nicholas at last called for the election of a Duma as proposed by his ancestor, Alexander I, a century before.

The first Duma was convened in 1906. The champions of autocracy were able to bring about its early dissolution. A second Duma was similarly dissolved after a short session, and the election law was changed by the government in such a way as to give the majority of the seats to the large manufacturing interests and the landlords. Though not fully representative, and limited in its powers, the Duma was an important step toward constitutional government. Dominated by property interests, it nevertheless attempted to bring about much-needed reforms, to exercise control over the government, and to protect individuals from arbitrary acts by government officials. The sanction of the Duma was required for the pass-

ing of any law, but it had no control over the governmental machinery for enforcing the law.

Russia and the First World War

The summer of 1914 saw fresh manifestations of discontent in Russia. Meetings of progressives and liberals, at which resolutions were passed demanding many reforms, were held, and strikes of unusual proportions developed in industrial centers. At this juncture, in August 1914, came the first World War. To well-informed observers it was no surprise. The relations between Russia and Germany, and between Russia and Austria, had been strained for several years past. Russia claimed special interests in the Balkans, which were imperiled by Austrian and German policies. There was also German influence inside Russia, especially in court circles, which was believed to be hostile to reform. This helped to make the war an internal as well as an external one, in the minds of the educated classes. But peasants and workmen at first accepted it without protest. All outward opposition to the government was submerged in the effort of the people as a whole to present a solid front to the enemy.

Russia felt the crushing burdens of the war sooner than other countries. Economic backwardness and poor means of communication made Russia's war effort extremely costly. The Russians' chief ports of communication with their allies in western Europe were shut off by the German fleet from the first day of the war. In spite of such use as could be made of Archangel during the summer season and the construction of a new railway to Alexandrovsk (now Polyarni) on the Arctic Ocean, Russia was subjected to a blockade almost as effective as that against the Central Powers; and Russia had always depended more largely than they upon foreign supplies.

Incompetence Brings Disaster

In this crisis, as many times before, the government proved itself incompetent and corrupt. The most progressive men of the country came forward with offers of assistance to the government in dealing with the problems of the war, but their offers were rejected. The government feared to grant popular participation in public affairs, lest this freedom lead to further embarrassment of the autocratic government. Great military disasters came to Russia as the result of the failure of the government to supply and equip the armies. Literally millions of Russian lives were sacrificed.

As a result, the attitude of the public toward the government changed, and there were demands for reforms, which alone would enable the nation to carry on the war. The sovereign listened only to the selfish advice of individuals in his immediate government circle, and interpreted all demands as either groundless or definitely unpatriotic. With his approval the government interfered in every way with the activities of the Duma and with the work of special organizations of the people, even those whose activities represented such genuine war work as the care of the wounded. The government's attitude was one of suspicion and often active hostility toward all movements initiated by the people.

By 1916 internal discontent, especially in the large cities, had swelled to alarming proportions. The food situation had become critical and prices on manufactured goods had risen to absurd heights. Again attempts were made to secure by petitions political changes which would better conditions, but again the sovereign refused to pay heed.

At Last the Government Collapses

In March 1917 a severe food shortage in the capital (then called Petrograd) caused an outbreak of rioting. The soldiers deserted the government and joined the people. The Duma, in session at the time, resolved to act to save the situation. It organized a temporary provisional government and sent a delegation to the Czar demanding his immediate abdication. The socialist members of the Duma formed a council of deputies from the workmen and soldiers of Petrograd. This council or "soviet" (as it is called in Russian) coöperated with the Duma committee in the selection of this first revolutionary government, and in drawing up its platform. Nicholas II abdicated for himself and his son (March 15), and was put under arrest. He and his family were sent to a distant Siberian monastery.

This revolution of March 1917 was accomplished within a week. The former government machinery in Petrograd collapsed utterly. The rest of the country, and particularly the army, promptly submitted to the new authority. There was little bloodshed, and the revolution was hailed with joy throughout Russia. For a time the government was in the hands of the nonsocialist Constitutional Democrats, but in July the power passed to Alexander Kerensky, a brilliant orator of moderate socialist views.

A program particularly favorable to the demands of labor and of the peasants was drawn up; but the executive machinery of the new government was not sufficiently perfected, and the people, unaccustomed to political responsibility, obstructed their own leaders at every turn. The economic situation was too bad to be immediately improved, and there were many differing opinions as to the best policy with respect to the war. Kerensky wanted to fight the Germans with renewed vigor, but this meant the increase of burdens already heavy. The Russian people were tired out, especially the peasants, and their losses in lives had already reached into the millions.

Bolsheviks Promise "Peace, Land, and Bread!"

At this point arose a group of extreme socialists who were schooled in the Communist doctrines of Karl Marx (*see* Marx). To many of them the recent revolution had given the opportunity to return from exile in foreign lands. They were few in number, although their name—Bolsheviks—means "majority men" (*see* Communism). But they were iron willed, they had a strong organization, a definite program, and a ruthless determination to carry it out. Of this group Nikolai Lenin was the undisputed leader (*see* Lenin). They aimed to overthrow completely Russia's social

and economic system and establish a dictatorship of the proletariat, or workmen, based on the principles of Communism (*see* Communism; Dictatorship).

With the downfall of the Czar there had sprung up spontaneously all over Russia thousands of soviets among workers, peasants, and soldiers. They had no clear program. The Bolsheviks carried on active propaganda among them, proclaimed "All power to the soviets!" and promised "Peace, land, and bread!" By October the party commanded a majority among the soviets of Petrograd and Moscow. The second All-Russian Congress of Soviets was scheduled to meet in Petrograd on November 7. Early that morning Red Guards poured into the city, surrounded the Winter Palace, and occupied the railroad stations, the ministries, and the state bank. When the Congress of Soviets met that night Lenin was proclaimed premier. (According to the old Russian calendar, then in use, the Bolshevik *coup d'état* took place October 25; hence the Revolution is usually called the October, or Octobrist, Revolution.) In Moscow and other cities there was bloody fighting; but within a week the Bolsheviks were masters of Great Russia. Eight months later the former Czar and his wife, son, and four daughters were shot by the Ural soviet (*see* Nicholas II).

BOLSHEVIST REVOLUTION LEADERS

Here we see Stalin talking to the novelist Maxim Gorky, on whom the Communist Academy bestowed the title of "proletarian writer."

The new government set about at once to abolish private property. It assumed ownership of all the land and took control of industry. An armistice was arranged with the Central Powers, and in March 1918 a treaty of peace was signed with the Germans at Brest-Litovsk. Germany was already in control of the Caucasus and the Ukraine. By the terms of this treaty Russia recognized Germany's claim to these rich provinces; and in addition agreed to give up Poland and the Baltic states and to pay a huge indemnity. The Bolsheviks paid a heavy price for peace—and gained only a short breathing space.

Civil War and Famine

Civil war broke out in 1918. "White" armies, under the leadership of former officers of the Czar, challenged the Red government. General Denikin led the Cossack forces in the south and Admiral Kolchak gained control of all Siberia. The Western Allies, who had been denounced as enemies by the Bolshevik leaders, supplied the White armies with war materials. British and American forces seized Murmansk and Archangel, and, with the Japanese, occupied Russia's Far Eastern ports. After the collapse and surrender of Germany in November 1918, the armies of liberated Poland invaded White Russia. The Red Army finally triumphed over Kolchak and Denikin, the Allies withdrew, and Lenin made peace with Poland. But Russia was more exhausted than ever.

The country had drifted into economic chaos. The government had taken over the railroads and industries, but had not yet learned how to run them. The people who had held responsible positions were regarded as enemies of the new régime. Many had been executed, and millions more had fled the country Money had become worthless, and manufactured goods were almost unobtainable. The peasants refused to hand over their produce to the government in exchange for promises. The government requisitioned the grain; and the peasants retaliated by raising less and hoarding. The harvest of 1920 was less than half the prewar average; and in 1921 came the Great Drought. Famine and disease stalked the land. The American Relief Administration fed millions, but many others died.

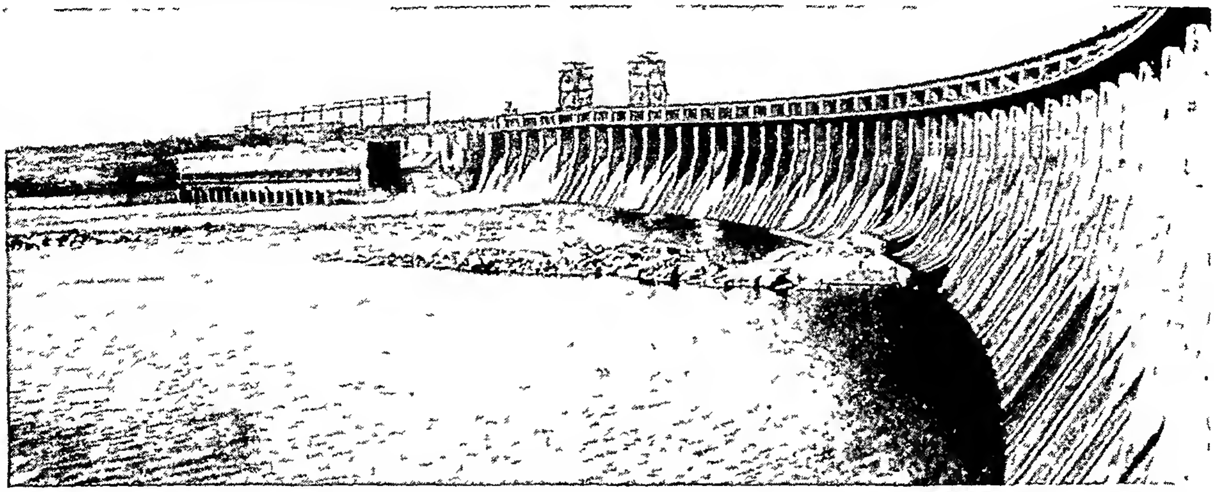
The government was forced to drop some of its Communist principles. In 1921 Lenin inaugurated the New Economic Policy (NEP), which allowed a partial return to individual initiative. The state retained its hold on heavy industry and the railroads. But individuals were again allowed to trade in private shops, to manufacture, and to make what profit they could, subject to taxes. Village handicrafts revived and the stalled wheels of industry began to turn again. The richer peasants (kulaks) were permitted by the new laws to rent additional lands and hire labor. Soon the total crop had almost reached the prewar level.

Stalin Succeeds Lenin

Lenin died in 1924, and a struggle for leadership began. Stalin and Trotzky had been closest to him (*see* Stalin; Trotzky). These two men clashed in temperament and policy. Lenin had said, "Only I can drive this ill-matched pair of horses." Of the two, Stalin was the ruthless "man of steel." As secretary of the Central Committee of the Communist party, he stripped Trotzky of power and exiled him in 1928. This *coup* made Stalin supreme dictator of Soviet Russia.

For a while Stalin continued Lenin's NEP. Money was put on a gold basis, and the old rubles exchanged

AN ACHIEVEMENT OF THE FIRST FIVE-YEAR PLAN



This dam on the Dnieper River, one of the largest in the world, supplied electricity for a large industrial district. To prevent its falling into the hands of the Germans, the Russians blew it up. Rebuilding began as soon as the Germans were driven out.

at the rate of two million to one. Foreign trade revived with confidence in the currency. The NEP men grew wealthy and the kulaks prospered. But corruption and graft had put in an appearance. Many of the kulaks (the name means "fist") held down the peasants under a weight of debt. The NEP men in the cities shared their profits with government officials in exchange for privileges. The government investigated and arrested tens of thousands. Business was again thrown into confusion.

The First Five-Year Plan

Meanwhile state industries were getting on their feet and Stalin felt the government was strong enough to abolish NEP and resume its drive toward a complete Communist economy. Year by year its forces were strengthened as the younger generation grew up, trained in Communist principles by the schools and youth organizations. Lenin had formed a state planning commission (*Gosplan*) and had begun a ten-year program for electrification. In 1928—which Stalin called "the year of great change"—the first of Russia's five-year plans was started. It called for the rapid building up of heavy industry, transforming the individual peasant into a collective farmer, and squeezing out utterly the capitalist elements. The plan charted the entire course of the nation's economic life. It prescribed how much coal was to be mined, how many factories built, and even how much food the people would eat. All the energies of the Communist party were concentrated on the program, and the political police (OGPU) ruthlessly suppressed all objectors.

Great difficulties had to be overcome. Foreign machinery and foreign experts were needed and had to be paid for. Russia's only chance to pay lay in exporting raw materials, principally foodstuffs. This meant that the peasants must produce a surplus, even though they were not yet producing enough to feed themselves and the rest of the country.

Huge "state farms" were established under government direction. Other peasants were ordered to pool their land and belongings into "collective farms." The kulaks resisted the changes, so a government decree ordered "the liquidation of the kulaks as a class." Their property was confiscated and the kulaks banished to slave labor in lumber camps or on the White Sea-Baltic Canal. Since any farmer, no matter how poor, who insisted on keeping his individual farm was denounced as a kulak, there was a rush to join the collectives. A considerable number of farmers countered with passive resistance. Rather than turn over their stock to the collectives, they slaughtered their cattle, sheep, goats, and pigs, and even the horses and oxen that pulled their plows. The government promptly seized all that they had saved for themselves. In the man-made famine that followed in 1932, about 3 million people died of starvation in the Ukraine alone. City workers too felt the pinch. Under the Communist plan, every city worker had a food card, entitling him to obtain supplies at government stores. Now, however, little food was available.

Nevertheless when the first five-year plan came to an end in 1932 the Soviet government announced that great progress had been made. The resistance of the peasants had been smashed and the country was started on the road to industrialization. The great Dnieper Dam had been completed and the production of coal, oil, pig iron, steel, and copper had doubled.

Stalin Purges the Party

Meanwhile the Communist party was being purged of all members who disagreed with Stalin. Trotzky and some 75 of his principal supporters were expelled from the party and sent into exile and hundreds of their followers suffered with them. An even greater "liquidation" took place from 1935 to 1936, when nearly a half million names were swept from the party rolls in the Great Purge. Eight generals of the Red army and 37 leading Bolsheviks were executed, and tens of thousands of party members were put into prisons and concentration camps. This pitiless

STALIN CHATS WITH LENIN

Lenin (left) tried to curb Stalin's growing power as secretary of the party; but when he died, Stalin succeeded him.

purge of former "comrades" completely solidified Stalin's grip on the government and the Red army.

Stalin's Foreign Policy

For 15 years after the Bolshevik Revolution the Soviet nation, confronted with staggering problems at home pursued a policy of isolation. Relations with other countries had long been disturbed by the worldwide activity of the Third, or Communist, International, known as the *Comintern* (*see* Communism). In every major country of the world, Stalin commanded Communist parties that could be used to gather information by espionage, to create discord, to undermine governments, and to foment civil strife. Like Lenin, he believed that the Soviet state would never be really secure until the entire world was Communist. While Russia was still militarily weak, however, Stalin aimed to prevent foreign attack by talking peace.

In Germany the Communist party played a major part in helping to destroy the democratic Weimar Republic—but its destruction brought Adolf Hitler to power on an outspoken anti-Communist program. Stalin then began to advocate "collective security" and ordered the Communist International to tone down its propaganda. The United States had up to this time refused to recognize the Soviet Union. With this seeming change in the Communist program, President Franklin D. Roosevelt granted recognition in 1933. In 1934 Russia joined the League of Nations.

HELPING TO MEET MOSCOW'S HOUSING SHORTAGE

This woman bricklayer is helping to build a new dwelling in Gorki Street in Moscow. Her thick padded clothes indicate the harshness of Moscow's "spring weather." In the communist system of government Russian women "comrades" work beside Russian men at even the hardest labor.

Stalin Makes a Pact with Hitler

In 1939 Britain and France sent missions to Moscow hoping to enlist Russia in an anti-Hitler alliance to prevent the outbreak of war. While these talks were proceeding publicly, Stalin was negotiating secretly with Hitler. On August 23 the world was stunned by the announcement that a Soviet-German nonaggression pact had been signed in Moscow. Each party promised to remain neutral if the other was attacked. Hitler now had the assurance he needed that he would not have to fight on two fronts at once. Nine days after the pact was signed, on September 1, Nazi troops and airplanes attacked Poland and World War II began.

In accordance with a prearranged plan, Soviet troops crossed the Polish frontier to occupy eastern Poland (September 17), which Hitler had promised to Russia. In November, Russia attacked Finland. Finnish resistance proved unexpectedly strong; but after the Finns had held off the Red armies for three months, they made peace on Russia's terms. In 1940, by agreement with Hitler, Russia annexed the Baltic States (Latvia, Lithuania, and Estonia) and began to organize them as Soviet republics. In the same year, Rumania was forced to cede to Russia Bessarabia and northern Bucovina. The Soviet Union, which had numbered 11 constituent republics, now numbered 16.

During the period of the Stalin-Hitler pact, the Soviet press and radio praised Hitler and denounced the British for going to the defense of Poland. All over the world Communist parties, following orders from Moscow, condemned the war as "imperialistic." Stalin supplied Hitler with millions of tons of grain and trainloads of metals and petroleum; but he also took measures to strengthen Russia's western border.

Hitler Hurls His Forces against Russia

Without warning, on June 22, 1941, German planes attacked Russian cities and German armies began to advance across the great Russian plain. In many villages the peasants welcomed the Germans, hoping they would put an end to the hated Communist rule. Millions of Russian troops surrendered rather than fight. Nazi brutality, however, soon turned the Russians against the invaders and fired their patriotism. Stalin himself said, "They are not fighting for the system, they are fighting for their soil."

As the Russians retreated, they stripped factories and sent the machinery to new plants in the Urals and Siberia. What they could not move, such as the Dnieper Dam, they wrecked.

By November, the Germans reached the suburbs of Moscow. In December Russia's severe winter brought

the German drive to a standstill. By spring, supplies from the United States and Britain were pouring in to aid Russia. Russian troops were soon eating American food, flying American planes, and riding in American jeeps, all supplied by American Lend-Lease aid.

The farthest advance achieved by the Germans was Stalingrad, on the Volga River, in 1942. Early in 1943 the Red army surrounded 22 German divisions in Stalingrad and forced their surrender. This battle marked the turning of the tide. In the summer Soviet armies went over to the offensive and steadily drove the Germans westward. In 1944 Russian troops entered Rumania and Hungary. By 1945 they had occupied all the capitals of eastern Europe except Athens and had entered Berlin itself.

Stalin at Yalta and Potsdam

In February 1945 Stalin met with Roosevelt and Churchill at Yalta, in the Russian Crimea. Stalin had signed a nonaggression pact with Russia's old enemy, Japan, in 1941. At Yalta, he promised to denounce this pact and enter the war against Japan three months after hostilities ended in Europe. As a reward, Russia was promised the Kuril Islands, the southern part of Sakhalin Island (from Japan), and certain rights in Manchuria, China's chief industrial area. Russia entered the war against Japan Aug. 8, 1945. The Red armies fought no battles, but by September 2, when the Japanese surrendered, they had moved into northern Korea and occupied much of Manchuria.

After Germany's unconditional surrender, the "big three" (Russia, the United States, and Great Britain) met again at Potsdam, a suburb of Berlin (July 17 to Aug. 2, 1945). Roosevelt had died and President Truman represented the United States. At this conference, Germany and Austria were each divided into four zones, each to be occupied by one of the "big three" nations and France. Berlin also was put under four-powered zone occupation, although completely surrounded by the Russian zone. German assets in eastern Europe and large reparations from Germany were assigned to Russia. Russian occupation of northern East Prussia and of Konigsberg was recognized.

Russia's "Satellites" in Europe

Stalin promised at Yalta and at Potsdam that in the countries Russia occupied there would be civil liberty, free elections, and representative governments. In all these countries, however, Moscow-trained political leaders, supported by the Red armies, succeeded in putting Communists into key positions. Anti-Communist leaders were soon dead, in jail, or in exile.

Bulgaria, Rumania, Albania, Hungary, Poland, and Yugoslavia became "people's republics," with governments modeled on that of Soviet Russia. In 1948 Czechoslovakia was brought into the Russian orbit also. Yugoslavia, in the same year, broke away from Russian control, but remained Communist. In 1949 the Russian zone in Germany was added to Russia's satellites as the German Democratic Republic.

The satellites, like Russia itself, were cut off from contacts with the Western world by what Winston Churchill called the "iron curtain"—restriction of travel and trade and rigid censorship of the press. Church leaders, particularly Roman Catholics, were persecuted because of their strong Western ties. Industries were gradually nationalized and small peasant farms were brought into large socialist "collectives." Freedom disappeared and the standard of living of the working people sank to a low level.

SOVIET RUSSIA PARADES ITS STRENGTH

Soldiers and tanks were introduced into Moscow's annual May Day parade to impress foreign observers with Russia's military strength. These pictures were taken in 1948.

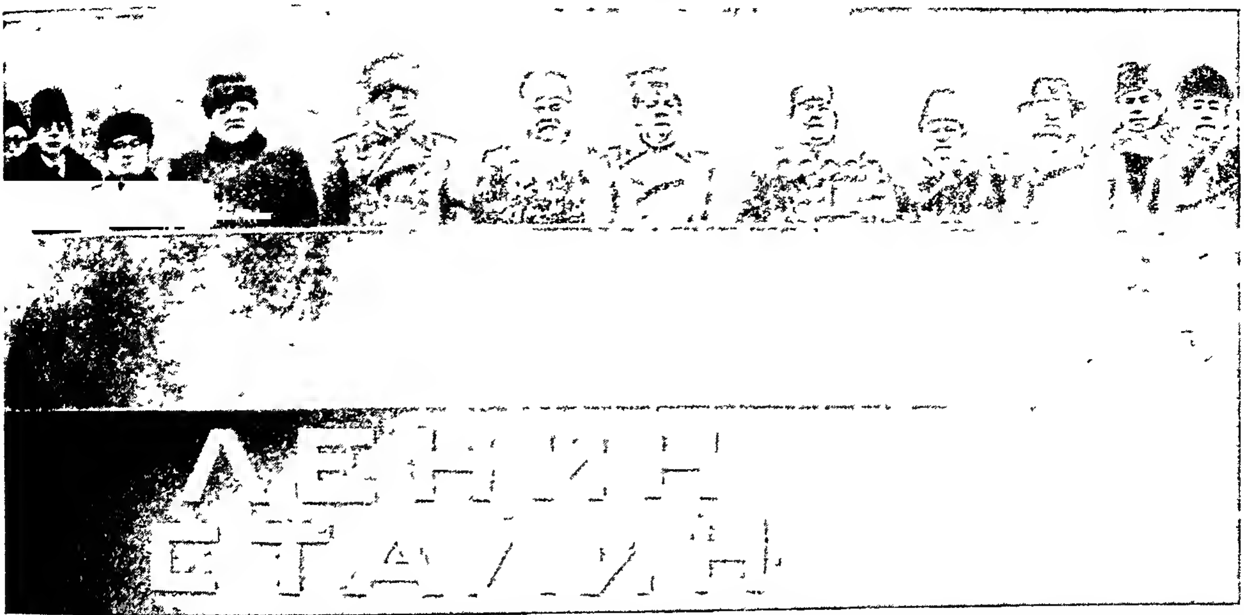
The "Cold War" between East and West

Russia became a charter member of the United Nations and a member of the "big five" on the Security Council. In the Council Russia repeatedly used its veto power to block disarmament and to prevent action against Soviet aggression. In the Council of Foreign Ministers it blocked efforts to write peace treaties for Germany and Austria.

Around its borders, Russia probed for weak spots in which to expand. Its satellites in southern Europe gave military aid to Greek Communists, who had plunged Greece into civil war. Russia itself made unsuccessful territorial demands on Iran and Turkey.

The turning point in the "cold war" came in 1947 when the United States offered military aid to Greece

COMMUNIST LEADERS GATHER FOR STALIN'S FUNERAL



In the Hall of Columns in Moscow's Red Square, Stalin was laid to rest beside Lenin, and his six-letter name was inscribed under Lenin's five letters. Left to right are Nenni and Togliatti from Italy, Duclos from France, Gottwald from Czechoslovakia, Bulganin, Molotov, Voroshilov, Malenkov, Khrushchev, Beria, Saburov, and Chou En-lai from China. In 1955 another shake-up in the Kremlin forced out Malenkov as premier. Bulganin replaced him. Zhukov became defense minister.

and Turkey under a program called the "Truman Doctrine." In the same year the United States inaugurated the Marshall Plan (European Recovery Program) for economic aid to Europe. Russia refused to allow Czechoslovakia or Poland to profit from the plan and attempted to counter its effect by hastily organizing the *Cominform* to bind together the Communist countries of Europe.

In 1948 Stalin attempted to drive the Western powers out of Berlin by blockading the city and starving the people. Britain and the United States broke the blockade, bringing in food by a gigantic "airlift."

On April 4, 1949, the United States, Canada, and most of the countries of Western Europe signed the North Atlantic Pact, providing that an armed attack against any one of them should be considered an attack against them all. This alliance checked Russia's expansion in Western Europe—but Russia was compensated by tremendous gains in Asia.

Russia Spreads Communism in Asia

In Asia also, Russia had its satellites. In 1924 Outer Mongolia had become a "people's republic." North Korea was quickly communized after 1945. From Manchuria, Soviet forces were partially withdrawn in such a way as to allow the Chinese Communists to take over much of the industrial area to use as a base for operations against the Nationalists in the Chinese civil war. Chinese Communists finally drove the Nationalist government off the mainland and set up a government modeled on that of Russia. In February 1950 Communist China signed a treaty with Russia of friendship, alliance, and mutual assistance.

The United Nations created the republic of South Korea when Russia refused to allow a free election to take place and unite the whole country. On June 25, 1950, Russian trained North Korean troops, using Russian tanks and equipment, invaded South Korea. The United Nations was able to take action against this aggression because Russia had temporarily boycotted the Security Council (*see* United Nations). Chinese "volunteer" troops in large numbers soon came to the aid of the North Koreans; and Russia supplied both armies with planes, tanks, artillery, ammunition, aviation gasoline, trucks, and other needed equipment.

Stalin's Death Marks the End of an Era

The Soviet press and radio had glorified Stalin as an all-wise "leader, father, and teacher" of the Soviet people. No provision was made, in the constitution or by Stalin himself, for his successor. On March 6, 1953, the Soviet radio announced Stalin's death. He had ruled Russia for 29 years.

A secret and bitter struggle began inside the Kremlin. No one man was strong enough to take over the absolute power wielded by Stalin. Georgi M. Malenkov was named chairman of the Council of Ministers and first secretary of the Communist party. Unlike Stalin, however, he was not to rule alone. Lavrenti P. Beria, chief of the secret police, headed the Ministry of Internal Affairs, which included both the secret police and the administration of slave labor camps. Vyacheslav M. Molotov was appointed foreign minister and Marshal Nikolai A. Bulganin, war minister. Marshal Georgi Zhukov, Russia's popular hero of World War II, was named a first deputy war minister.

Within a week Malenkov, "at his own request," gave up the powerful post of first secretary of the Communist party to Nikita Khrushchev. Intrigue filled the Kremlin. In June Beria was secretly arrested and accused of "criminal activity," particularly of plotting to restore capitalism in Russia. After a secret trial Beria was executed in December 1953.

Unrest in the Satellite Countries

Russia had imposed Communism on its satellite nations by terrorism. In an effort to weaken the Red tyranny many workers used sabotage. Even before Stalin's death, Red leaders admitted that there were production losses from damaged goods and defective machinery. Refugees from Communism poured into Western Europe, especially into free West Berlin.

After Stalin's death, Soviet leaders made some concessions. Malenkov pledged better living conditions, saying he would put less emphasis on developing heavy industry and more on consumer goods. Unrest persisted. A mass demonstration against Red rule broke out in June 1953 in East Berlin. Rioting spread in East Germany, and Soviet troops moved in with tanks.

From "Cold War" to "Big Four" Talks

In its world policy, Russia continued its disturbing tactics, with one exception. It encouraged North Korea to sign a truce with the United Nations in 1953 (*see* Korea). Otherwise Russia carried on its "cold war" with the democracies, blocking a peace treaty with Austria, denying free elections in East Germany, and refusing to accept international control of atomic weapons. It also helped Red China to support Communist rebels in Indo-China (*see* Indo-China).

Hints of more trouble in Russia, however, came in March 1955 when Malenkov "resigned" as premier. He "confessed" to the failure of his "goods for the people" plan. He was succeeded by Bulganin.

When the democracies made West Germany a sovereign nation, May 5, Russia retaliated by signing a military pact with its satellite nations. The Allies' firm stand, however, and Soviet internal troubles turned Russia to new tactics. On May 15 it signed the treaty to free Austria. On the day before, Premier Bulganin agreed to meet for talks in July 1955 at Geneva with President Eisenhower, Prime Minister Eden of Great Britain, and Premier Faure of France.

REFERENCE-OUTLINE FOR STUDY OF RUSSIA (UNION OF SOVIET SOCIALIST REPUBLICS)

THE LAND AND THE PEOPLE

I. **Location and size** R-256-7, chart U-246, list R-256: location in world, map W-205; in Asia, map A-406, picture A-413; political divisions, map R-260; air distances, polar projection map A-531

II. **Structure of the land** R-256-61, A-414, map R-259
- A. **Mountains** R-257, list R-256: Caucasus C-155-6; Mount Elbrus, picture R-258; Siberia S-174; Tien Shan T-213; Urals U-404-5
- B. **Rivers** R-257, S-174, list R-256: Volga V-520
- C. **Lakes and seas** R-257, list R-256: Lake Aral A-293-4; Lake Baikal B-18; Black Sea B-204; Caspian Sea C-132

III. **Climate** R-257-8, C-349, S-172, A-413, map R-261

IV. **Republics of the Soviet Union** R-261-2, map R-260
- A. **Russian Soviet Federated Socialist Republic** ("Russia Proper") R-256-292*b*
- B. **European Soviet Socialist Republics:** Estonian E-400; Latvian L-135; Lithuanian L-276; Ukrainian U-233; Georgian G-81; Armenian A-373-5; Karelo-Finnish, White Russian (Byelorussian), Moldavian, Azerbaidzhan (Fact-Index)
- C. **Asiatic Soviet Socialist Republics:** Kazak, Turkmen, Uzbek, Tadzhik, Kirghiz T-214

V. **The people** R-262-3, pictures R-258, 262-4, 269, 274, 283, 291, A-403: Armenians A-374; Cossacks C-489-90, picture R-257; Lapps L-101-2; Mongols M-346; Slavs S-198, Tatars T-23; nomads A-414-15
- A. **Population:** compared with other countries, chart U-246, graph P-371; movement from country to city R-269
- B. **Farm life** R-263-4, picture R-271: collective farming A-70, R-264, 269, pictures R-276, E-430; stock raising and dairying R-276-7
- C. **City life** R-269-70, pictures L-163, 164
- D. **Class distinction and slave labor** R-270-1
- E. **Propaganda:** art, science, radio, and the press serve the state R-271, 275
- F. **Recreation,** picture R-258: holidays R-271 (Christmas, Easter, and New Year R-273); May Day parade, picture R-274; sports R-271, 274 (wrestling W-307)

VI. **Resources and industries** R-276-80, U-405, C-156, A-416, P-315, list R-256, products maps R-278-9
- A. **Agriculture** R-276, map R-278: collective farming A-70, R-264, 269, pictures R-276, E-430; cotton R-276, map C-493; land planning and use L-96, R-276; soil types R-258, 261; stock raising and dairying R-276-7
- B. **Forests and forest products** R-258, 277, C-156
- C. **Fisheries** R-277: Caspian Sea C-132; seal S-88-9; sturgeon S-434
- D. **Furs** R-277, picture R-276
- E. **Minerals and mining** R-277, 280, S-174, maps E-429*d*, R-279: petroleum P-169, C-156, R-277, 280, C-132; uranium U-405; mineral production compared with the United States, graph R-280
- F. **Water power** R-280, picture R-290
- G. **Manufacturing** R-280, M-398, L-164, K-38, K-39, O-340: five-year plans R-280, 290; government ownership and control of industry R-270

VII. **Trade** R-281, O-340, table I-192: ports R-261. See also Trade, table in Fact-Index

VIII. **Transportation and communication** R-280-1: aviation, picture R-276; Baltic-White Sea Canal C-108; Moscow-Volga Canal, picture R-281; railroads R-281 (Chinese Eastern Railway C-282, M-75, 76; Trans-Siberian Railway R-281, S-173); railway and highway mileage compared with United States, graph R-280; Ukraine K-38

IX. **Principal cities** R-280, list R-256: Moscow M-396-9, pictures R-256, 269, 272; Leningrad L-162-4, picture R-286; Kharkov K-38; Kiev K-39; Odessa O-340; Astrakhan A-426; Gorki, picture R-258

X. **Education** E-263, R-273-4: Siberia, picture S-173

XI. **Science** R-275: polar exploration P-350, 350*a*, 351, map P-346, table P-349

XII. **The arts** R-275, picture R-273: literature R-294-6. See also the Reference-Outline for Language and Literature

XIII. **Government** R-281-3: Communist party R-275, 281-3, C-426-7; Komsomols (Young Communists) R-274, 281-2

XIV. **Religion** R-272-3, 263

HISTORY

I. General R-283-292*b*, chart H-364-8: rulers of Russia before 1917 Revolution, table in Fact-Index
II. Early history: Slav settlements R-283-4: Goth and Hun invasions G-143, H-451
III. Northmen use Dneiper River to establish trade route from Scandinavia to Byzantium R-284
IV. Rurik founds first Russian dynasty R-284
V. Christianity introduced at Kiev (988) K-39, R-284
VI. Mongolian Tatar hordes invade and dominate Russia for 250 years R-284-5, M-345, G-37
VII. Rise of Moscow—the founding of modern Russia R-285, M-396-8: Ivan III, the Great I-283; Ivan IV, the Terrible, the first czar I-283, R-285
VIII. The "time of troubles" R-285
IX. Romanov dynasty begins with Michael R-285-6
X. Russian empire "westernized" and expanded under Peter the Great and Catherine II, the Great R-286, P-166-7, C-140
  A. Peter builds a new capital at St. Petersburg (now Leningrad) L-162-3
  B. War with Charles XII of Sweden C-195, P-167
  C. Estonia and Latvia annexed E-400, L-135
  D. Partition of Poland P-344
XI. Imperial Russia to the Revolutions of 1917 R-286-8
  A. Alexander I and the Napoleonic Wars A-147, N-10: Congress of Vienna V-471
  B. Reactionary reign of Nicholas I N-233-4, R-286-7: Crimean War C-513-14, R-286; Alaska sold to the United States A-137
  C. Alexander II—reform and then reaction A-147, R-287: emancipation of the serfs R-287; war with Turkey T-220*a*, B-26; revolutionaries assassinate the "czar liberator" A-147
  D. Revolutionary agitation grows during reign of Alexander III R-287, A-147: Jewish pogroms throughout Russia J-354; construction of the Trans-Siberian Railroad S-173
  E. The last imperial reign—Nicholas II N-234, R-287-8: Russo-Japanese War R-296, P-13; Duma, representative assembly, is convened R-287-8; France and England, with Russia, form the Triple Entente T-177, E-266
  F. Europe on the eve of World War I E-434: Russia mobilizes W-216-17
  G. World War I R-288, W-215-44. See also in Fact-Index World War I and chronology
  H. Russia collapses R-288, W-226: czar abdicates after Revolution of March 1917 N-234, Kerensky forms provisional government R-288
  I. Bolsheviks led by Lenin seize control after the October Revolution of 1917 R-288-9
XII. Dictatorship established D-88, R-289: Lenin L-162; Trotsky T-192; Stalin S-361
  A. Treaty of Brest-Litovsk R-289, W-226
  B. Territorial losses: Bessarabia R-254; Estonia E-400; Finland F-72; Latvia L-135; Lithuania L-276; Poland (eastern) P-344
  C. Nicholas II and family murdered by soviets at Ekaterinburg (Sverdlovsk) in 1918 N-234
  D. Civil war between "white" and "red" armies W-240-1, R-289
  E. Reds triumph and Russia falls into internal chaos R-289, L-164: Communist government established in Moscow's Kremlin M-398
  F. Stalin succeeds Lenin R-289-90, S-361-2: foreign policy R-291
XIII. The Soviet Union before World War II R-290-1, S-361-2: suppression of the church R-272; the five-year plans R-280, 290; Stalin purges the party R-290-1; foreign policy R-291
  A. War with Finland F-72
  B. Estonia, Latvia, and Lithuania become republics of the Soviet Union E-400, L-135, L-276
XIV. World War II R-291-2. See also in Fact-Index World War II and chronology
  A. The Soviet-German pact R-291, W-247, picture W-248
  B. Partition of Poland W-248, P-345
  C. Germany invades the Soviet Union R-291, W-257-8, 261-2: Russians counterattack W-264-6, 268-9, 270-1, R-292 (battle of Stalingrad W-278, S-362); Russians capture Berlin W-284, B-130
  D. Russia declares war on Japan W-272, R-292
  E. Allied conferences and postwar agreements R-292: Tehran (1943) W-297, picture W-298; Yalta and Potsdam (1945) W-298-9, G-100
XV. Peace treaties and territorial gains E-437, R-292, 292*a*, W-299*b*-300, 301
XVI. Soviet "satellites" in Europe and Asia R-292, W-300, E-437-8
  A. Countries behind the "iron curtain" in Europe: Albania A-138; Bulgaria B-348; Czechoslovakia C-536; German Democratic Republic G-102, Hungary H-448; Poland P-345; Rumania R-252; Austria (Soviet zone) A-495
  B. Countries behind the "iron curtain" in Asia: China C-285; Manchuria M-76; Mongolia M-341; North Korea K-65-6; Tibet T-129
XVII. The "cold war" between East and West U-242, R-292-292*a*
  A. Soviet Russia in the United Nations U-240-3
  B. Soviet aggression in the Middle East: Iran I-223-4; Turkey T-220*b*
XVIII. Death of Stalin R-292*a*, S-362: unrest in the satellites R-292*b*
XIX. Communist aggression in Southeast Asia A-420: Malaya M-60; Indo-China I-126

BIBLIOGRAPHY FOR RUSSIA

THE LAND AND THE PEOPLE

Books for Younger Readers

Baker, N. B. Peter the Great (Vanguard, 1943).
Cohn, Norma. Little People in a Big Country; Pictures by Children of Soviet Russia (Oxford, 1945).
Erskine, Dorothy. Russia's Story (Crowell, 1946).
Kalashnikoff, Nicholas. The Defender (Scribner, 1951).
Malvern, Gladys. Dancing Star: the Story of Anna Pavlova (Messner, 1942).
Nazaroff, A. I. Land of the Russian People (Lippincott, 1944).
Prishvin, M. M. Treasure Trove of the Sun (Viking, 1952).
Reyher, R. H. My Mother Is the Most Beautiful Woman in the World (Lothrop, 1945).
Tolstoy, A. N. Russian Tales for Children (Dutton, 1947).

Books for Advanced Students and Teachers

Bauer, R. A. The New Man in Soviet Psychology (Harvard Univ. Press, 1952).
Chamberlin, W. H. The Russian Revolution, 1917–1921, 2v. (Macmillan, 1935).
Cressey, G. B. The Basis of Soviet Strength (Whittlesey, 1945).
Dallin, D. J. New Soviet Empire (Yale Univ. Press, 1951).

Deon, Vera. The United States and Russia (Harvard Univ. Press, 1948).
Fischer, Louis. Life and Death of Stalin (Harper, 1952).
Goodfriend, Arthur. If You Were Born in Russia (Farrar, Straus 1950).
Gordey, Michel. Visa to Moscow (Knopf, 1952).
Horcave, Sidney. Russia; a History (Houghton, 1952).
Kirchner, Wolther. Outline-History of Russia (Barnes & Noble, 1950).
Pores, Sir Bernard. History of Russia (New American, 1952).
Seeger, Elizobeth. Pageant of Russian History (Longmans, 1950).
Seton-Wotson, Hugh. Decline of Imperial Russia, 1855–1914 (Praeger, 1953).
Shobad, Theodore. Geography of the USSR (Columbia Univ. Press, 1951).
Steinberg, Julien, ed. Verdict of Three Decades (Little, 1950).
Vernadsky, George. History of Russia (Yale Univ. Press, 1951).
Wolfe, Bertram. Three Who Made a Revolution (Dial, 1948).

LITERATURE AND THE ARTS

Bunin, I. A. Memories and Portraits (Doubleday, 1951).
Chekhov, A. P. Portable Chekhov (Viking, 1947).
Dostoyevsky, F. M. Brothers Karamazov (Winston, 1949).
Jelogin, Juri. Taming of the Arts (Dutton, 1951).
Tolstoy, L. N. War and Peace (Winston, 1949).
Turgeniev, I. S. Fathers and Sons (Modern Library, 1951).
Yarmolinsky, Avrahm, ed. Treasury of Great Russian Short Stories: Pushkin to Gorki (Macmillan, 1947).
Yarmolinsky, Avrahm, ed. Treasury of Russian Verse (Macmillan, 1949).

The SWEEPING POWER *of the* RUSSIAN WRITERS

RUSSIAN LITERATURE. Out of the vast land of Russia has come a unique literature. Its character is rooted in people who have lived close to the soil. Russian stories and plays have the slow patience of nature. They are often brooding and fatalistic, like the lives of the peasants who face bleak winters and brief, hot summers with resignation. Throughout the whole literature is a deep devotion to "Mother Russia."

LOMONOSOV
Father of Russian Literature

Fortunately for Americans almost all great Russian works have been translated into English. Otherwise the language barrier would be formidable. Russian is a Slavic language, and English-speaking people find it hard to learn. Its grammar is intricate, and it is written in the Cyrillic alphabet, derived in the 9th century from the Greek alphabet and other sources. Actually, three languages are spoken in Russia: (1) Great Russian, in the northern, central, and eastern regions; (2) Little Russian, the language of the Ukraine in southern Russia; and (3) White Russian, in the west. But Great Russian was the official language of the old Russian Empire, and it alone has produced a great literature.

PUSHKIN
Byronic National Poet

Beginnings of Russian Literature

The first Russian literary monuments were written in "Church Slavonic," the old language still used in the Russian Orthodox Church. The 'Chronicle of Nestor,' compiled about 1100, has supplied many writers with historical and legendary material. But an epic poem, 'The Lay of the Host of Igor', is the earliest real literary work which has survived. It was composed about 1185 by an unknown author, probably in Kiev, a medieval cultural center. The Tatar invasion in the 13th century blighted intellectual life for more than two centuries. In later centuries internal troubles hampered literary production. But in the 18th century, a real national literature emerged.

The First Great Literature

During the first half of the century, Mikhail Lomonosov ruled the literary world of Russia much as Dr. Johnson did that of England. He is often called the "father of Russian literature." The great period, however, really began in the reign of Catherine the Great. She turned the interest of her court toward France, making the French language and culture fashionable. The first Russian comedy of manners, Denis Fonvizin's 'The Minor', was published during her reign. Ivan Krylov, Russia's LaFontaine, also wrote his fables at this time.

Russia's first literary giant was Alexander Pushkin, one of the world's greatest lyric poets. Besides his exquisite lyrics, he wrote a notable novel in verse, 'Eugene Onegin'. It depicts the life of Russia's gentry in the first quarter of the 19th century. Onegin, was the first "superfluous man." He provided the subject of later novels, among them Mikhail Lermontov's 'A Hero of Our Time'. In this book Lermontov, Russia's second great poet, created the first Russian psychological novel.

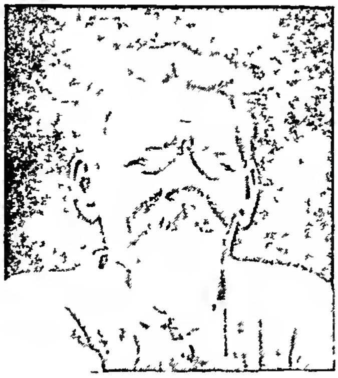
GOGOL
Founder of Russian Realism

Nikolai Gogol began a new age of prose. His most famous work, 'The Inspector-General', is one of the world's greatest comedies. In many of his stories his themes were the tragedy of the "little man" and the corruption of Russia's landed gentry.

Ivan Goncharov continued the plight of the superfluous man in his novel 'Oblomov'. This title has

become a synonym in Russian for the well-meaning aristocrat with no ambition and nothing to do. The early novels of Ivan Turgeniev continued to probe into the souls of Russia's "Oblomovs." At this time, writers came more and more to feel that literature should have social significance and that Russian culture should be based on that of Western Europe. Foremost among these "westernizers" were the critics Vissarion Belinsky and Alexander Herzen.

Turgeniev's novels form a record of the gradually developing social philosophy of Russia. His 'Sportsman's Sketches', sometimes called Russia's 'Uncle Tom's Cabin', revealed the evils of serfdom. 'Fathers and Sons' dealt with the philosophy of nihilism, and his last great novel, 'Virgin Soil', with Populism (*see* Turgeniev).



GORKY
Defender of the Underdog

The Golden Age of Russian literature reached its climax in the works of Dostoyevsky and Tolstoy. Feodor Dostoyevsky, student of the human soul, was the most "Russian" of the great novelists. His powerful psychological novels have influenced the literature of all countries. Count Leo Tolstoy, at once social reformer, philosopher, and great artist, had a mind of broader scope. Many consider his masterpieces, 'War and Peace' and 'Anna Karenina', the world's greatest novels (*see* Tolstoy).

BABEL
Writer of Cavalry Tales

The great period closed with the masterful plays and stories of Anton Chekhov and Maxim Gorky. Among the last of the pre-Revolutionary realists to attain lasting fame were Leonid Andréev, Ivan Bunin, Vladimir Korolenko, and Alexander Kuprin. In the 1890's symbolism spread from France to Russia. There it found expression in the poetry of Alexander Blok, the greatest and most "Russian" of the symbolists, and of Andrey Byely.

Writers and the Revolution

When the Revolution of 1917 came, Russian writers were divided in their attitude toward it. Some, like Bunin and Andréev, refused to accept it and chose exile. Others, like Alexei N. Tolstoy (a distant relation of Leo Tolstoy) and Gorky, hesitated a little then accepted the Communist revolutionary régime. Tolstoy's 'Road to Calvary' and 'Peter the Great' are significant in post-Revolutionary literature.

Some authors had been willing to accept the Revolution though they would not approve all its tenets. Trotzky dubbed them the "poputchiki" or "fellow travelers." With their emergence around 1921, a new age began. Important writers of those years were the novelists Boris Pilnyak and Vsevolod Ivanov; the peasant writer Lydia Seifullina; Sergei Yessenin, the husband of Isadora Duncan; and Isaac Babel, whose vivid tales of the Red cavalry are masterpieces.

During the period of the Five-Year Plans other talented writers came to the fore. Leonid Leonov and Feodor Gladkov wrote of the modernization and industrialization of Russia, while Valentin Katayev, Panteleimon Romanov, and Mikhail Zoshchenko gently satirized life under the Soviets. After 1932, Maxim Gorky was regarded as the dean of Russian writers. The important guiding principle of "Socialist Realism" is ascribed to him. This principle states that literature must express faith in the Communist theory of the state and must support Communism. Writers of the 1930's and 1940's also turned to the past and glorified the feats of the great emperors and military heroes in innumerable historical novels.

SHOLOKHOV
Tolstoy's Literary Successor

About 1935, younger writers, educated during the Soviet régime, began to come forward. Among them were Mikhail Sholokhov and Alexander Fadeyev. Sholokhov's magnificent epic novel 'The Quiet Don' has been called the new 'War and Peace.'

Russia's writers reflected the total mobilization of the second World War. Most prominent spokesman for Russian ideas during those years was the former bourgeois writer Ilya Erenburg. A younger writer, Konstantin Simonov, wrote a successful novel about the siege of Stalingrad, 'Days and Nights'. He is regarded as the foremost writer of present-day Russia.

CHIEF FIGURES IN RUSSIAN LITERATURE

Mikhail Lomonosov (1711–1765), poet and grammarian—"father of Russian literature."
Denis Fonvizin (1744–1792), satirist and playwright—'The Brigadier-General'; 'The Minor'.
Nikolai Karamzin (1765–1826), critic and historian—'Poor Liza'; 'History of the Russian State'.
Ivan Krylov (1768–1844), satirist and fabulist.
Vasili Zhukovsky (1783–1852), critic and translator.
Alexander Griboyedov (1795–1829), dramatic poet—'The Misfortune of Being Clever'.
Alexander Pushkin (1799–1837), poet, dramatist, novelist—'Eugene Onegin'; 'Boris Gudenov'; 'Queen of Spades'.
Nikolai Gogol (1809–1852), realistic novelist and dramatist—'The Inspector-General'; 'Taras Bulba'; 'Dead Souls'.

Vissarion Belinsky (1810?–1848), critic and essayist.
Ivan Goncharov (1812–1891), novelist—'A Common Story'; 'Oblomov'; 'The Precipice'.
Alexander Herzen (1812–1870), critic and journalist.
Mikhail Lermontov (1814–1841), lyric poet and novelist—'The Demon'; 'A Hero of Our Time'; 'The Angel'.
Ivan Turgeniev (1818–1883), novelist—'A Sportsman's Sketches'; 'Fathers and Sons'; 'Virgin Soil'.
Feodor Dostoyevsky (1821–1881), psychological novelist—'Notes from Underground'; 'Crime and Punishment'; 'The Idiot'; 'The Possessed'; 'Brothers Karamazov'.
Nikolai Nekrasov (1821–1877), poet and journalist.
Alexander Ostrovsky (1823–1886), dramatist—'The Storm'.
Leo Tolstoy (1828–1910), novelist, dramatist, philosopher—'War and Peace'; 'Anna Karenina'; 'My Confession'; 'Kreutzer Sonata'; 'Death of Ivan Ilyich'; 'Resurrection'.
Mikhail Saltykov (Shchedrin) (1826–1889), satirist and novelist—'The Golovev Family'.
Nikolai Leskov (1831–1895), short-story writer and novelist—'The Enchanted Wanderer'; 'The Cathedral Folk'.
Vladimir Korolenko (1853–1921), author of Siberian tales and short stories.
Anton Chekhov (1860-1904), dramatist and short-story writer—'The Darling'; 'The Steppe'; 'Uncle Vanya'; 'Three Sisters'; 'The Cherry Orchard'.
Maxim Gorky (Alexis Peshkov) (1868-1936), novelist, short-story writer, and dramatist—'Chelkash'; 'Twenty-six Men and a Girl'; 'The Lower Depths'; 'Mother'.
Ivan Bunin (1870-1953), novelist, short-story writer, and poet—'Gentleman from San Francisco'; 'The Village'.
Alexander Kuprin (1870–1938), short-story writer and novelist—'The Duel'; 'The Bracelet of Garnets'; 'Yama'.
Leonid Andréev (1871–1919), dramatist and short-story writer—'The Red Laugh'; 'The Seven That Were Hanged'.
Alexander Blok (1880–1921), symbolist poet—'Verses about the Beautiful Lady'; 'The Scythians'; 'The Twelve'.
Andrey Byely (Boris Bugaiev) (1880–1934), poet and novelist—'The Silver Dove'; 'Moscow'; 'Petersburg'.
Alexei N. Tolstoy (1882–1945), novelist—'Peter the Great'; 'Bread'; 'Road to Calvary'.
Feodor Gladkov (1883–), novelist—'Cement'; 'Power'.
Panteleimon Romanov (1884–1936), short-story writer, novelist—'Without Cherry Blossom'; 'Three Pairs of Silk Stockings'; 'Russia'.
Lydia Seifullina (1889–), short-story writer and novelist.
Boris Pasternak (1890–), poet—'My Sister'; 'Life'.
Ilya Erenburg (1891–), novelist, journalist—'Adventures of Julio Jurenito'; 'The Fall of Paris'; 'The Storm'.
Konstantin Fedin (1892–), novelist—'Cities and Years'.
Vladimir Mayakovsky (1894–1930), poet and dramatist—'The Cloud'; 'Left March'; 'Mysteria-Bouffe'; 'Lenin'.
Boris Pilnyak (1894–), short-story writer and novelist—'The Naked Year'; 'Leather Jackets'.
Isaac Babel (1894–), short-story writer—'Stories of the Red Cavalry'; 'Tales'.
Sergei Yessenin (1895–1925), poet and poetic dramatist.
Mikhail Zoshchenko (1895–), short-story writer, humorist.
Vsevolod Ivanov (1896–), short-story writer and novelist.
Valentin Katayev (1897–), playwright and novelist—'The Embezzlers'; 'Squaring the Circle'; 'Time, Forward'.
Leonid Leonov (1899–), novelist and playwright—'The Badgers'; 'Road to the Ocean'; 'The Chariot of Wrath'.
Alexander Fadeyev (1901–), novelist—'The Nineteen'; 'Last of the Udegs'; 'The Young Guard'.
Mikhail Sholokhov (1905–)—'The Quiet Don'; 'Seeds of Tomorrow'; 'They Fought for Their Country'.
Konstantin Simonov (1915–), journalist, poet, dramatist, novelist—'Days and Nights'; 'Russian People'.

RUSSO-JAPANESE WAR (1904–1905). Before the first World War, this was considered one of the greatest military struggles of all times. It opened a new chapter in the history of the Far East, marking a new era in the national life of Japan and tremendously advancing her power. The British, who had feared Russia's pressure on India, saw that power go down like a card house before Japan, with whom England was allied.

Japan had been embittered at the close of her successful war against China, in 1895, by the demand of Russia, Germany, and France that she evacuate Port Arthur and the Liaotung Peninsula, ceded to her by defeated China. She yielded, but was deeply angered when three years later Russia seized this territory for herself. Japanese discontent was increased a few years later when Russia made the Boxer troubles in China an excuse for occupying Chinese Manchuria, under pretext of guarding her railroad and other interests there. Japan pressed Russia to keep her promises to withdraw from Manchuria, but Russia quibbled and evaded. A Russian concession for timber cutting in the Yalu Valley was protested against as the beginning of an attempt to bring Korea under Russian control. But Russia blindly blundered on toward the inevitable war, for which she was far from being prepared.

Japan struck deceptively in February 1904. Without a declaration of war, the Russian Far Eastern fleet at Port Arthur was torpedoed. The conflict was on, with Japan efficient and ready, and Russia weak because of the ignorance and corruption of many of her leaders. Port Arthur was besieged by the Japanese army under General Nogi and the fleet under Admiral Togo. Japanese armies swarmed into the peninsula and drove the Russians back in a series of disgraceful defeats. The chief disaster was at Mukden, in February 1905, when Oyama defeated Kuropatkin, Russia's greatest general. The Russian fleet from Europe was crushed in May as soon as it arrived, in the great battle of the Sea of Japan. The single-track line of the Trans-Siberian Railroad proved inadequate to bring up supplies and reinforcements. Russia was soon in utter collapse.

Finally President Theodore Roosevelt brought about a peace conference in Portsmouth, N.H. The resulting Treaty of Portsmouth (Sept. 5, 1905) gave Russia's rights in Port Arthur and the Liaotung Peninsula to Japan, and gave her also the southern half of the island of Sakhalin. Russia agreed to evacuate Chinese Manchuria, and recognized Japan's paramount interest in Korea.

This Russian defeat contributed materially to the downfall of the czars 13 years later.

RUST. A red ash forms when iron "burns" by uniting with oxygen dissolved in water. This is iron oxide, or rust. Soil has varying amounts of iron oxide, and so red soil is actually "rusty" soil. Rust is slightly soluble in water, and in this form it is taken up and used by plants. Men and animals get the iron they need by eating the plants. Iron gives the color to the red corpuscles in the blood.

Most forms of iron and steel will rust in moist air. When a drop of rain falls on a clean bright

surface of iron, the drop stays clear for a short time. But soon rust begins to form from the union between the iron and the oxygen in the water. At first the water has a greenish color, and then assumes the familiar reddish brown. The rust hangs in the water, and coats the iron only when the water evaporates. Steam will not rust iron until it cools and condenses on the surface of the iron.

Once started, rust will spread even though the atmosphere is fairly dry. The rough rust spots help what moisture there is in the air to condense. Thus it is easier to prevent the formation of rust than to stop it from spreading. Rust may be prevented by coating the surface with a zinc or lead oil paint.

Iron or steel articles may be held in storage for a long time without rusting by coating them with a plastic film. They may also be preserved in an air-tight chamber containing silica gel or activated alumina. Larger surfaces, such as the interiors of naval vessels not in use, are kept rust-free by "dehumidifiers" which draw moist air out of the compartments and replace it with dry air. (*See also* Alloys.)

Rusts and smuts. Minute parasite plants belonging to the group of fungi called *Basidiomycetes* prey upon our most valuable cereals and cause crop losses that total hundreds of millions of dollars every year. Not only do these diseases reduce the yield, but the harvested grain if smutted or rusted receives a lower grade in marketing or is rejected entirely. Wheat, oats, and barley are the crops chiefly affected, but rye, corn, beans, clover, a great many grasses, and some of the stone fruits also suffer seriously. In addition huge losses to the lumber industry are caused by a white-pine blister rust. Rusts and smuts are found practically the world over. So great is the economic injury done that national and state governments are investing vast sums in research into the causes, prevention, and cure, and in educating farmers to coöperate in warring against them.

Like mushrooms and other members of the big *fungi* family, "rusts" and "smuts" reproduce themselves by means of spores, tiny dustlike bodies, invisible except under a microscope (*see* Fungi). Black stem rust of wheat makes an interesting type study. It feeds at different stages on two different plants, which botanists term its "hosts." One host is the wheat plant, the other is the common barberry.

On the underside of the barberry leaf we find masses of orange-colored spores in little depressions called "cluster-cups." These spores, lighter even than dust particles, are easily carried by the wind for many miles. Falling upon the young wheat stalks, they lodge among the living cells and germinate, forming a threadlike mass called the "mycelium," corresponding to the spawn in mushroom culture. By appropriating the wheat's food, this filament flourishes while the useful plant is stunted.

When "Red" and "Black" Rusts Appear

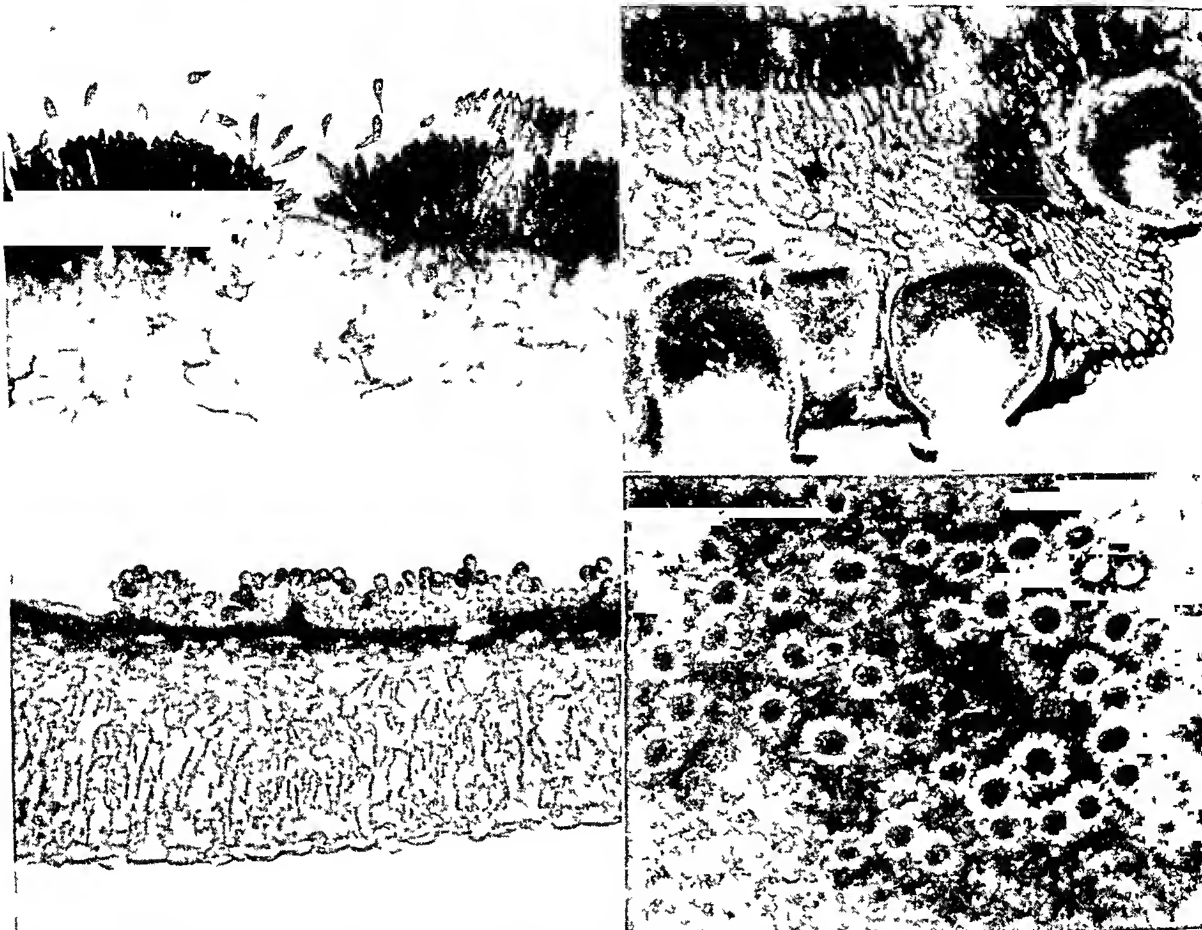
Before harvest time the crop of summer spores appears as rusty-looking lines or dots, usually upon the leaves but sometimes upon the stalk also. This is the "red rust" of wheat. Scattered by the wind upon nearby plants, these spores quickly germinate, spreading the disease with fearful rapidity during the growing season. Later in the summer "black rust" emerges upon the wheat stems as masses of dark-colored winter spores. These germinate the next spring, forming a filament that produces more spores for the wind to waft to the barberry leaves, ready to begin the deadly cycle all over again.

There are many kinds of rusts. One species alone, black stem rust, has more than 60 different forms which attack wheat, oats, barley, rye, and about 100 grasses, both wild and cultivated. Some species of rust have only one host, others have several. In the case of the white-pine blister rust, the secondary host may be either the black currant or gooseberry bush, the eradication of which is urged to save our white pine forests.

FOUR RUSTS AND SMUTS AND THE GRAINS THEY RUIN

Here is the work of rusts and smuts upon wheat (1), barley (2), oats (3), and corn (4). To the left of the shriveled stalks of the first three is a fine healthy head of the same grain with plump well-developed kernels. The smutted ear of corn with its distorted kernels is almost as distressing a sight as a case of human disease.

ENLARGED VIEWS OF THE FARMER'S FOES

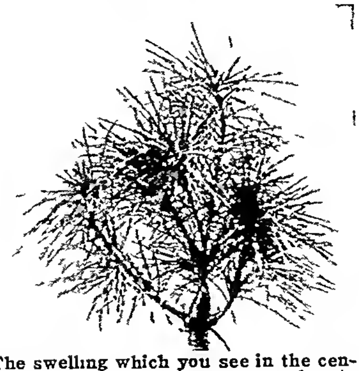


In the upper left-hand corner the winter spores of wheat rust are shown breaking from the wheat stalk in spring. To the right is a section of barberry leaf with "cluster cups" full of spores on the under side. In the lower left corner is a section of grass leaf which is furnishing pasture for a fine crop of one-celled summer spores of rust which can germinate on wheat without passing through the barberry stage. What looks like a group of daisies on the right is a daisy leaf on which are growing cluster cups of another species.

The smut fungus has a less complex history. In the case of smut of wheat, oats, and barley, the spores are clinging to the seed when sown. The fungus enters the plantlet soon after it sprouts, grows up with it, steals its food, and usually prevents it from forming seed. Instead, smeary smut masses form, consisting of millions of spores that in the threshing and handling attach themselves to the sound grains, thus endangering the next crop.

Corn smut is different in origin, being caused not by infected seed but by spores which have wintered either on the ground or in the manure used as fertilizer. When spring comes these spores produce others which the wind distributes over the cornfield, to penetrate the young corn plants. Large boil-like growths develop which gradually darken, forming "smut balls."

STILL ANOTHER RUST



The swelling which you see in the central stem of this young pine is due to white pine "blister rust," one of the worst enemies of the forest giants.

Smuts are spoken of as "loose," "covered," and "stinking" smuts. Loose smut changes the spikelet into a sooty mass which the wind blows away, leaving the stalk bare. Heads affected by covered smut remain on the stalk until the harvest. Stinking smut, or "bunt," affects only wheat kernels and is one of the most destructive wheat diseases, sometimes causing the loss of half the crop. The powdery mass inside the smutted grains smells like decaying fish.

For the prevention of grain rusts, experts are pinning their strongest hopes to the development of new varieties of grain able to resist the fungus. Important experiments in breeding and selection are in progress at agricultural stations all over the country. Hard red wheat has been found to offer good resistance. Early-maturing varieties escape the excessive rain and "muggy"

weather of late summer, conditions under which the rust plant thrives. Crop rotation helps to cure rust-infected soils. Excess of either nitrogen or moisture favors the infection. For many years "banish the barberry" has been the war cry in grain-growing districts, and many states have now passed anti-barberry laws. Though the barberry stage is not always needed, it helps the spread of wheat rust. Some species of barberry do not act as host to the parasite.

Smuts lend themselves more readily than rusts to the preventive methods of modern agriculture. That is because the smut spores cling to the outside of the seeds and may be killed by disinfecting before sowing. For this purpose three treatments are in common use—by hot water, formaldehyde, and copper carbonate. Bulletins of the Department of Agriculture at Washington furnish complete and up-to-date information regarding materials, apparatus, and formulas. They may be obtained free by writing for them. Disinfected seed needs, however, to be tested for germination before planting. Because of the peculiar character of corn smut, treating the seed is of no value. The only remedy is to burn the smutted stalks as they are discovered in the field. Fortunately this smut does not do an important amount of damage. Early seeding is usually strongly advised as a protection against smut as well as rust.

Ruth. In the days when the "Judges" ruled in the land of Israel—so the Bible tells us in the beautiful story of Ruth—a certain man of Bethlehem had gone with his wife Naomi and his two sons to dwell in the land of Moab. There he died and later the two sons, who had married Moabite women, also died. Sad and lonely, Naomi decided to return to her old home. So with her daughters-in-law, Ruth and Orphah, she started for Bethlehem.

Before they had gone very far, Naomi told her companions to return to their homes. Only grief and loneliness were in store for them if they followed her into a strange land. "Go, my daughters," she said, "return each to your mother's house, and may the Lord deal kindly with you as you have dealt with my sons and me." Then she kissed them, with many tears. Orphah kissed her mother-in-law and went back. But Ruth clung to her and would not go back. "Entreat me not to leave thee," she said, "or to return from following after thee: for whither thou goest, I will go; and where thou lodgest, I will lodge: thy people shall be my people, and thy God my God: where thou diest, will I die, and there will I be buried: the Lord do so to me and more also, if aught but death part thee and me."

So Ruth and Naomi went on together, and they reached Bethlehem in the time of the barley harvest. It was the custom in those days for the poor to go into the fields and pick up (glean) the grain which the reapers had left behind. Ruth went out to glean so that she and Naomi might have food. She came to the field of a wealthy kinsman of her husband's, named Boaz. He noticed Ruth as she gleaned among the reapers, and he asked after her. And when they told him who she was, and how she had left her native land to come to a strange place, he was deeply moved by her loyalty to Naomi. He spoke kindly to Ruth, telling her to come again to his field. He commanded his young men to treat her with respect and told them to let some of the grain fall on purpose for her.

Ruth returned home very happy that evening and described the great kindness of Boaz. "The man is one of our near kinsmen," said Naomi. So day after day Ruth gleaned in the field of Boaz; and at the end of the harvest he "took Ruth and she was his wife." They were very happy together, and still more happy when a son was born to them. They called him Obed, and in after years Obed became the father of Jesse, the father of David, one of the kings of Israel. The story is in the Book of Ruth in the Old Testament.

"ENTREAT ME NOT TO LEAVE THEE"

With these heartfelt words, Ruth begs her mother-in-law, Naomi, to take her from the land of Moab to Bethlehem, Naomi's home. The story is told in the Book of Ruth in the Old Testament. This scene is from a picture by Philip Calderon that hangs in the Walker Art Gallery of Liverpool, England.

Ruth, George Herman (Babe) (1895–1948). The crowd that jammed Wrigley Field booed when the big man with the barrel-shaped body and pipe-stem legs strode to the plate. It was the third game of the 1932 World Series between the Chicago Cubs and the New York Yankees. The score was 4-4 in the fifth inning.

Cub pitcher Charlie Root threw one strike, then another. Grinning, the batter stepped back and seemed to point to the distant center field

bleachers. Root pitched, the big man swung, and the ball soared into the bleachers for a home run.

The big fellow was Babe Ruth, the most popular man who ever played baseball. The pointing gesture, whether he meant it or not, was typical of the way the Babe captured the imagination of baseball fans.

His achievements bulk large in the record books. He held or shared in about 60 records, with 28 made in world series games. Among them are his total of 714 major league homers—not including 15 world series homers—and his feat of pitching 29⅔ consecutive scoreless innings in world series play.

Ruth was born in Baltimore, Md., Feb. 6, 1895. His father, a saloonkeeper, placed him in St. Mary's Industrial School when the boy was 7. There he learned to play and to love baseball. In 1914, through the help of Brother Gilbert, one of the brothers who taught at the school, Ruth began to play with the Baltimore Orioles of the International League.

The Orioles' manager, Jack Dunn, paid him $600 for his first season. Although Ruth later earned such nicknames as the Sultan of Swat and the Busting Bambino, he got his most famous nickname—Babe—on his first day of practise with the Orioles. A seasoned veteran took one look at the tall youngster and sneered, "Here's another one of Dunn's babes."

That same year, 1914, he was sold to the Boston Red Sox. Eventually, as his prowess with the bat grew, he was shifted from the pitcher's box to the outfield, where he could play every day. Before he quit pitching, Ruth compiled a record of 92 victories and 44 losses. Baseball writers insist he was proudest of his hurling record.

In 1920 Ruth was sold to the New York Yankees. Then began the greatest years of his career. He reached his peak in 1927 when he hit 60 home runs, a season record which still stands. His team mates and fans knew him as a huge eater and a great practical joker, always involved in some good-natured scrape. He was married twice. His first wife died in 1928 and he married again in 1929.

As he grew older, the weight of his huge body became too great a burden for his slender legs. In 1935, after 15 years with the Yankees, he went to the Boston Braves as a playing vice-president. It was an unhappy period for Ruth, and before finishing the season, he laid down his bat for the last time.

In 1947 Ruth, who had always loved children, took a position with the Ford Motor Company to help with its Legion junior baseball program. He died in 1948 of a throat cancer, with one dream unfulfilled. He had always wanted to manage a big league team.

THE BABE SELECTS A BAT

In his last playing year Babe Ruth wore the uniform of the Boston Braves. Here he stands in front of the dugout, choosing a bat before stepping to the plate.

RYE. In the northern countries of Europe where wheat does not grow well, rye is the principal breadstuff. From it is made the common "black bread" and "pumpernickel." Usually rye flour contains the whole substance of the grain, and therefore is richer in protein than white wheat flour.

Rye (*Secale cereale*) is a cereal grain closely related to wheat. There are fewer varieties than of any other important grain, and all may be classified as winter or spring types. Rye does not seem to have been cultivated by any peoples in ancient times. Its early home was in Europe, probably in the region north of the Black Sea. Rye is hardier than wheat. It grows on poorer, lighter soils, in mountainous regions, and in cold northern countries. Rye does not grow in the extreme north, however, as well as barley does.

Rye is sometimes called "the grain of poverty" for it will grow on poor soils. When grown on land good enough for wheat it will become thick, stout, and seven feet tall. The world's production of rye is less than one fourth that of wheat. Russia, Poland, Germany, Czechoslovakia, and Hungary are the chief producers. In the United States rye is of minor importance compared with wheat or corn. The rye crop usually ranges from a twentieth to a fiftieth of the wheat crop.

Ground rye and rye bran are used as stock feed. Rye straw is longer and more uniform in size than that of other grains. It is used in the manufacture of paper, pasteboard, and hats. It is also used for thatching roofs in parts of Europe and for stuffing horse collars.

The rye plant is too strong and wiry to make good forage for cattle, though it is grown in England for this purpose. Another objection to it as a forage crop is liability to attack by a poisonous fungus. The fungus (*Claviceps purpurea*) grows in place of the grains and forms horny masses called "ergot."

THE EASY REFERENCE FACT-INDEX

GUIDE TO ALL VOLUMES FOR SUBJECTS
BEGINNING WITH

Q-R

TO SAVE TIME

USE THIS INDEX ☞

EDITOR'S NOTE ON NEXT PAGE TELLS WHY

EDITOR'S NOTE ON NEXT PAGE TELLS WHY

SPECIAL LISTS AND TABLES

Numerous other lists and tables in the fields of geography, history, literature, science, mathematics, and other departments of knowledge will be found with their appropriate articles in the main text

EDITOR'S NOTE

EVERY user of Compton's Pictured Encyclopedia should form the habit of *first* turning to the Fact-Index section at the end of each volume when in search of specific information. This index is a miniature work of reference in itself and will often give you directly the facts, dates, or definitions you seek. Even when you want full treatment of a subject, you will usually save time by finding in the index the exact page numbers for the desired material.

All page numbers are preceded by a letter of the alphabet, as A-23. The letter indicates the volume. If two or three page numbers are given for the topic you are seeking, the first indicates the more general and important treatment; the second and third point to additional information on other pages. Where necessary, subheadings follow the entry and tell you by guide words or phrases where the various aspects of the subject are treated.

The arrangement of subheadings is alphabetical, except in major historical entries. In these the chronological order is followed.

The pictures illustrating a specific subject are indicated by the word *picture* or *color picture* followed by a volume indicator and a page number. A picture reference is frequently intended to call attention to details in the text under the illustration as well as to the illustration itself. This picture-text, therefore, should always be carefully read. The pictures are usually on the same page as the text to which you are also referred; sometimes they are found in a different but related article which will add interest and information.

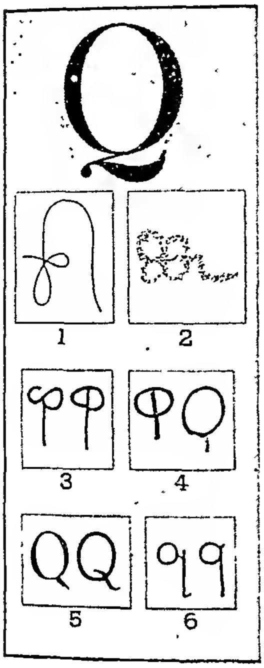
The pronunciations given are those preferred by the best and most recent authorities; alternative pronunciations are indicated where usage is divided.

In recent years hundreds of foreign geographical names have been changed, either officially or by custom. Both old and new names are given at the appropriate places in the alphabet.

Populations are those of the latest census or an official estimate when available if no census has been taken since World War II. Distances between points are map or air distances, not distances by railroad.

THE EASY REFERENCE FACT-INDEX

Reg. U. S. Pat. Off.



As NEARLY as anyone can tell, our letter Q started in Egyptian writing as some form of a looped rope, perhaps as a picture (1) which meant 'lasso'. Soon after 2000 B.C., a Semitic people called the Seirites adopted this sign as an alphabetic sign for a deep, throaty 'k', because their word *kaw* (pronounced somewhat like *qaow*) began with this sound.

They made the sign with several small loops (2). Later the Canaanite-Phoenician alphabet developed simplified forms (3). In all Semitic languages, the name of this sign resembled the Hebrew term *koph*.

When the Greeks learned how to write from the Phoenicians, they renamed the sign *koppa* and used it for several centuries (4). But to the Greeks the sound indicated by the sign *koppa* was exactly like the sound indicated by the Greek K, or *kappa;* so gradually the Greeks dropped *koppa* as useless. Before this happened, however, the Romans had learned to write from the Greeks, and they had acquired the early Greek habit of using *koppa* for a 'k' sound before *u*. They called the letter *koo* and eventually they gave it a round form with a curved tail (5). In this form the letter came from Latin into English; and English follows Latin in using 'q' for a 'k' sound before *u*.

Our small 'q' developed from the old Greek *koppa* between the 6th and the 9th centuries after Christ, with a shift of the circle from the top to the left (6).

NOTE.—For the story of how alphabetic writing began and developed, *see* the articles Alphabet; Writing.

Quintil'ian (Marcus Fabius Quintilianus) (A.D. 35?–95?), famous Roman teacher of oratory; wrote 'Institutio Oratoria', a complete treatment of the art of rhetoric place in Latin literature L-131

Quintilis, former Roman name for July J-364

Quintuplets. *See in Index* Diligenti quintuplets; Dionne quintuplets

Quintus Fabius Maximus (died 203 B.C.), Roman general H-259–60

Quipu (*kē'pọ*), ancient Inca device for keeping records I-50

Quir'inale, palace in Rome, Italy R-191, *map* R-190

Quirinal Hill, Rome, Italy R-194

Quirino, Elpidio (born 1890), Filipino political leader, born Vigan on Island of Luzon; vice-president and foreign secretary, Republic of the Philippines, under President Manuel Roxas 1946–48; president 1948–53: P-202

Quiri'nus, name of Romulus after he became a divinity R-198

Quirites (*kwi-rē'tēz*), name applied to citizens of ancient Rome in their civil or domestic capacity, *Romani* being reserved for military or foreign affairs.

Quiros, Cesáreo Bernaldo de (born 1879), Argentine painter; noted chiefly for paintings depicting the life of the gaucho.

Quisling, term applied to a traitorous citizen who helps an enemy power to conquer and control his own country; derived from name of Vidkun Quisling (1887–1945) who proclaimed himself premier of a Nazi-controlled government in Norway a few hours after the German invasion, April 1940; recognized as premier by Hitler 1942; shot as traitor 1945: W-250

Quitch grass Q-1, *picture* Q-1

Quito (*kē'tō*), capital of republic of Ecuador in n., about 15 mi. s. of equator; pop. 209,932; university; the northern capital of Incas until taken by Spaniards in 1534: E-232, *maps* P-164, S-252, *picture* E-231
temperature E-231
university library books, *picture* L-203

Quivira (*kē-vē'rä*), Indian settlement of reputed wealth and splendor sought by Coronado C-486

Quixote, Don (*dŏn kwiks'ŏt*, Spanish *dōn kē-hō'tā*), character in book by Cervantes C-179, S-326

Quoins. *See in Index* Architecture, *table* of terms

Quoits, a game Q-14

Quonset hut, a long, steel building semicylindrical in shape; named for Quonset Point, R. I., where first used by Navy during World War II; served as shelter and warehouses for armed forces; later used as residential, commercial, and industrial buildings: G-213, *picture* S-143

Quo'rum, the number of members of an organized body whose presence is necessary for legal transaction of business; in the United States Congress a quorum is a majority of all members.

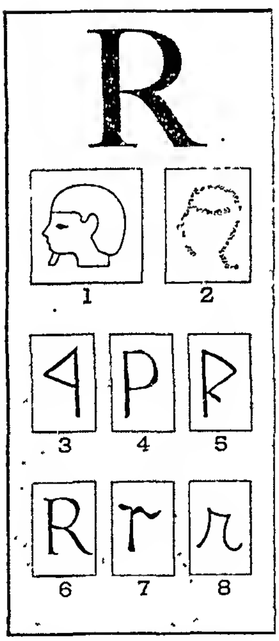
Quota, proportional part or share
immigration I-47–8
international trade I-196
marketing, agricultural A-68–9

Quota sampling, in statistics S-385*b*

Quotation marks, use of P-438

Quotient, in arithmetic D-107, 108
decimal D-31

'Quo Vadis' (*kwō vä'dis*) (Latin, "Whither goest thou?"), historical novel of the time of Nero by Henryk Sienkiewicz.



Our letter R probably started in Egyptian writing as a finely done little picture (1) which meant 'head'. Soon after 2000 B.C., it acquired a new meaning when a Semitic people called the Seirites adopted it as an alphabetic sign for the sound of 'r'. They did so because their name *resh* for 'head' began with this sound.

The Seirites imitated the Egyptian sign crudely (2). The Canaanite-Phoenician alphabet simplified the sign and straightened the curves. The resulting triangle pointed left, because this was convenient for writing in Semitic fashion from right to left (3). All Semitic names for this sign resembled the Hebrew name *resh*.

When the Greeks learned how to write from the Phoenicians, they took over the *resh* sign, but they turned it around for greater ease in writing from left to right. They also renamed it *rho* and sometimes gave it a graceful curve (4). Other forms had a slight tail (5).

The Romans took this sign into Latin. But their sign for P came to look almost the same, so they gave the Greek *rho* a pronounced tail (6). In that form the letter came into English.

The small handwritten 'r' got a start in Greek as a rounded form of the capital. In medieval times the curved stroke was made toward the right to connect with the next letter (7). This form came into English and was simplified into our present handwritten form (8). The printed small 'r' omits the right-hand down stroke of the handwritten one.

Note.—For the story of how alphabetic writing began and developed, *see* the articles Alphabet; Writing.

'R-34', British airship B-34

Ra, Egyptian deity. *See in Index* Re

Raab, Hungary. *See in Index* Györ

Raabe (*rä'bŭ*), **Wilhelm** (1831–1910), German novelist; eccentric characters ('Die Chronik der Sperlingsgasse'; 'Der Hungerpastor'; 'Der Schüderump').

Rabat (*rä-bat'*), a fortified seaport in Morocco; seat of government in French zone and one of sultan's capitals; pop. 156,209; Hassan Tower, a splendid minaret of an old mosque: *maps* A-167, A-46

Rabaul (*rạ-boul'*), New Guinea, until 1941 capital of Mandated Territory of New Guinea, on n.e. coast of New Britain Island; pop. 7600: *maps* E-203, P-16

Rabbi (*răb'ī*), official title of Jewish ministers; a Hebrew word meaning "my master," originally applied to scholars and teachers of the law; used in New Testament as a title of respect in addressing Christ: J-351

Rabbit and hare R-15–19, *pictures* R-15, 17–18
altitude range, *picture* Z-362
Australian pest A-480, R-16
coloration, protective R-18
commercial raising R-18
cottontail R-16, *picture* N-56
differences between R-15
domestic breeds R-18
fur R-18
length of life, average, *pictograph* A-249
name of male and female R-15, 16
nest R-15, *picture* N-56
pets, care of P-182*a*–*b*, *picture* P-182*a*
speed due to leg structure R-16
story 'Hare and Tortoise' F-3
tracks R-16: in snow, *picture* N-45
trap for T-177

Rabbit fever. *See in Index* Tularemia

Rabbit Islands, group 3 mi. w. of coast of Asiatic Turkey and 7 mi. s. of Dardanelles; largest island 1 mi. long and 800 yds. wide; group awarded to Turkey 1923 by Treaty of Lausanne.

Rabelais (*rà-bĕ-lā'*), **François** (1493?–1553), celebrated French satirist and humorist R-19
influence on French language F-287

Rabi (*rä'bi*), **Isidor Isaac** (born 1898), American physicist, born Austria; to U. S. in infancy; physics professor Columbia University after 1937; received 1944 Nobel prize in physics "for resonance method of recording magnetic properties of atomic nuclei."

Rabies. *See in Index* Hydrophobia

Rabiru'bia, or yellowtail, salt-water food fish, belonging to snapper family found in southern waters.

Raccoon (*ră-kọn'*), or coon R-19–20, *pictures* R-20, P-186

Raccoon Mountains, in n.o. Alabama;

RAILROAD MILEAGE FOR COUNTRIES OF THE WORLD

Alaska	567	Great Britain	19,863	Norway	2,484
Algeria	2,786	Greece	1,621	Panama	400
Argentina	26,710	Guatemala	537	Paraguay	749
Australia	28,471	Haiti	200	Peru	1,947
Austria	4,450	Honduras	920	Philippines	600
Belgian Congo	2,976	Hungary	4,773	Poland	13,375
Belgium	3,209	India and Pakistan	40,823	Portugal	2,102
Bolivia	1,608	Indo-China	1,200	Puerto Rico	400
Brazil	21,251	Indonesia	4,600	Rumania	7,363
Bulgaria	1,996	Iran	1,600	Russia (Europe and Asia)	57,487
Burma	1,777	Iraq	1,000	Salvador, El	385
Canada	43,085	Ireland, Northern	754	Siam (Thailand)	1,926
Ceylon	913	Ireland, Republic of	2,463	South West Africa	1,500
Chile	5,726	Israel	200	Spain	10,563
China	12,960	Italy	11,383	Sudan	2,013
Colombia	2,106	Jamaica	300	Sweden	10,518
Costa Rica	600	Japan and Korea	12,572	Switzerland	3,345
Cuba	6,000	Latvia	2,102	Syria	1,000
Czechoslovakia	8,383	Libya	200	Tunisia	1,273
Denmark	2,263	Lithuania	1,045	Turkey (Europe and Asia)	4,882
Dominican Republic	800	Luxemburg	332	Union of South Africa	13,931
Ecuador	687	Malaya, Federation of	1,068	United States	223,427
Egypt	3,440	Manchuria	5,243	Uruguay	1,905
Estonia	911	Mexico	14,981	Venezuela	700
Ethiopia	500	Morocco	1,080	Yugoslavia	6,926
Finland	3,533	Nepal	100	Other countries	8,824
Formosa	2,440	Netherlands	2,114		
France	40,348	New Zealand	3,528		
Germany	36,256	Nicaragua	300	Total	783,679

SOME RELIGIOUS BODIES

(United States membership, based on latest available data)

Adventist bodies	298,000
Assemblies of God	370,000
Baptist bodies	17,991,000
Brethren (German Baptists)	234,000
Catholic churches *See* Eastern Orthodox churches, Old Catholic churches, and Roman Catholic church	
Christ Unity Science church	1,581,000
Churches of Christ	1,500,000
Churches of God	356,000
Church of God in Christ	338,000
Church of the Nazarene	250,000
Congregational Christian churches	1,284,000
Disciples of Christ	1 848,000
Eastern Orthodox churches	2,100,000
Evangelical and Reformed church	761,000
Evangelical United Brethren church	728,000
Friends	117,000
Greek Orthodox *See* Eastern Orthodox churches	
Jewish congregations	5,000,000
Latter-day Saints	1,213,000
Lutheran bodies	6,609,000
Mennonite bodies	158,000
Methodist bodies	11,642,000
Mormon *See* Latter day Saints	
Old Catholic churches	100,000
Pentecostal assemblies	284,000
Polish National Catholic church	266,000
Presbyterian bodies	3,635,000
Protestant Episcopal church	2,551,000
Quakers *See* Friends	
Reformed bodies	391,000
Roman Catholic church	31,476,000
Russian Orthodox *See* Eastern Orthodox churches	
Salvation Army	236 000
Spiritualists	166,000

introduced into Europe C-522
pest, bobolink B-219
producing regions R-147, 149
China C-269–70, R-147, *map* C-262, *pictures* C-263, 270–1
East Indies, *pictures* E-206, R-147
Indo-China I-124, R-147, *picture* I-122
Japan J-305, R-147
Malay Peninsula M-59
Philippines P-199, *picture* P-193
Siam (Thailand) S-169, 170
South America, *pictograph* S-246
United States R-149: Arkansas A-360; California, *picture* C-39; Louisiana L-322, A-66
slave labor A-195
starch made from S-382
threshing R-147, *picture* P-42*b*
vitamins in R-149, V-494–5, 497
wedding symbolism M-101*a*

Ricebird, common name of a number of beautiful Oriental birds; the Java sparrow, a cage bird, and other members of the *Ploceidae* family which feed on rice
name for bobolink B-219

Rice Institute, at Houston, Tex.; founded 1912 by William Marsh Rice, who originally endowed it with his entire fortune of $10,000,000; arts and sciences, architecture, engineering, physical education; graduate studies: *picture* T-96

Richard, Saint, of Wyche (1197?–1253), English saint and bishop of Chichester, festival April 3.

Richard I, the Lion-Hearted (1157–99), king of England R-149–50, *picture* R-150
Château Gaillard R-150, *picture* N-243
John and J-358, R-149, 150
leads Third Crusade C-520, R-149, *pictures* C-520, R-150
municipal charters D-64
Robin Hood legends R-165

Richard II (1367–1400), king of England R-150–1
Chaucer's official career C-200
drama by Shakespeare, chronology and rank S-129
Henry IV overthrows H-336, R-151
Wat Tyler's rebellion T-227, R-150

Richard III (1452–85), king of England R-151
drama by Shakespeare, chronology and rank S-129
murder of the princes E-266

Richard, Gabriel (1767–1832), French Roman Catholic missionary, Michigan pioneer; fled Revolution-torn France to labor first among French and Indians in Illinois, then in Detroit province, including Michigan and Wisconsin territory; tried to restrain liquor traffic of trading posts, exercised great influence over Indians, opened schools, imported first printing press and looms; delegate to Congress 1822–24.

Richards, Ellen Henrietta (1842–1911), pioneer of home economics movement, born Dunstable, Mass.; instructor at Massachusetts Institute of Technology ('Chemistry of Cooking and Cleaning'; 'The Cost of Living'): H-409

Richards, Laura Elizabeth (1850–1943), author, born Boston, Mass., daughter of Julia Ward Howe; prolific writer of verses and stories for children, girls' stories, and biographies of famous women ('Florence Nightingale'; 'Margaret Montfort'; 'Captain January'; 'Hildegarde' series).

Richards, Theodore William (1868–1928), physical chemist, born Germantown, Pa.; taught at Harvard University from 1894; made many important physical chemistry experiments; awarded Nobel prize 1914 for redetermination of atomic weights of many chemical elements.

Richard Saunders, pen name used by Benjamin Franklin F-280*a*

Richardson, Dorothy M. (Mrs. Alan Odle) (born 1882), English novelist ('Pilgrimage', work of several volumes): E-383

Richardson, Henry Handel, pen name of Ethel Florence Lindesay Richardson, also called Henrietta Richardson (Mrs. John C. Robertson) (1870–1946), Australian novelist, born Melbourne, Australia; later lived in London; after writing for 20 years, became famous with 'Ultima Thule' (1929), the closing volume of a trilogy on Australian life entitled 'The Fortunes of Richard Mahoney'; first two volumes were 'Australia Felix' and 'The Way Home'.

Richardson, Henry Hobson (1838–86), architect, born Louisiana; revived Romanesque influence: S-358

Richardson, John (1797–1863), Canadian journalist and novelist; served in Canadian militia in War of 1812, and in regular British army: C-105

Richardson, Sir Owen Willans (born 1879), English physicist, born Dewsbury, Yorkshire, England; professor of physics Princeton University 1906–14, at King's College, London, 1914–44, emeritus professor University of London after 1944; Nobel prize in physics 1928.

Richardson, Sir Ralph (David) (born 1902), English actor of stage and screen, born Cheltenham, England; knighted 1947 for services to English theater; successful stage roles include Peer Gynt and Falstaff.

Richardson, Samuel (1689–1761), English novelist N-311, E-378*a*

Richardson Trophy, annual award by Golf Writers Association for the most important nonplaying contribution to golf during the year.

Richard Yea and Nay, name given Richard I, of England, because he changed his plans so readily R-150

Richberg, Donald Randall (born 1881), lawyer and public official, born Knoxville, Tenn.; defended labor against corporations; coauthor Railway Labor Act (1926) and NIRA (1933); general counsel NRA 1933–34; head policy committee to supervise NRA 1934–35.

Richelieu (*rish'ĕ-lụ*, French *rē-shĕ-lyû'*), **Cardinal** (1585–1642), French churchman and statesman R-151–2, *picture* R-152
Corneille and C-486, *picture* R-152
in Thirty Years' War T-119

Richelieu River, in Quebec province, Canada, outlet of Lake Champlain connecting with St. Lawrence River at Lake St. Peter; about 80 mi. long; discovered by Champlain; route of early explorers.

Richepin (*rĕsh-păṅ'*), **Jean** (1849–1926), French poet, dramatist, novelist; vigorous, outspoken style ('Les Caresses', 'Les Blasphèmes', verse; 'Grandes amoureuses', 'Flamboche', novels; 'Nana Sahib', 'Le Chemineau', 'Don Quichotte', plays).

Richet, Charles (1850–1935), French physiologist, born in Paris; professor of physiology, University of Paris; awarded Nobel prize (1913) for work on sensitivity of body to serum injections.

Richfield, Minn., village 6 mi. s. of Minneapolis; pop. 17,502: *map* M-287

Richland, Wash., in Benton County, 9 mi. n.w. of Pasco, on Columbia River; pop. 21,809; built on federal property 1943–45 to house workers on Atomic Energy Commission's installation: *maps* U-252, W-45
Hanford Operations Office W-38

Richmond, Grace Smith (Mrs. Nelson Guernsey Richmond) (born 1866), novelist and short-story writer, born Pawtucket, R. I.; her stories are simple, wholesome, and entertaining ('Red Pepper Burns'; 'Red and Black'; 'The Listening Post').

Richmond, Calif., city on San Francisco Bay, 8 mi. n.e. of San Francisco; pop. 99,545: R-152, *map, inset* C-34

Richmond, England, residential suburb 9 mi. s.w. of London; pop. 41,945: *map, inset* B-325

Richmond, Ind., industrial city and farming center 68 mi. e. of Indianapolis, on Whitewater River; pop. 39,539; farm implements, overalls, kitchen cabinets, caskets; settled 1816 by Friends from North Carolina; Earlham College: *map* I-79

Richmond, Ky., town 25 mi. s.e. of Lexington; pop. 10,268; agricultural center; tobacco and livestock market; Eastern Kentucky State College; decisive victory of Confederates under Gen. E. Kirby Smith 1862: *map* K-31

Richmond, Va., state capital on James River; pop. 230,310: R-152–3, *maps* V-487, U-253
capital of Confederate States C-433, R-153, *maps* C-334–5: Capitol, *picture* C-433*a*
Capitol, State R-153, *picture* V-490
Civil War C-334, 336, R-153, *maps* C-334–5: devastation of war R-153, *picture* R-85*a*
Davis monument D-23
Federal Reserve Bank (5th) and district, *map* F-49
first electric street railway S-430
Jefferson makes Richmond state capital J-332*a*
St. John's Church, *picture* V-491

Richmond, Borough of, New York City; coextensive with Staten Island; pop. 191,555: N-216, 226, *maps* N-222, *inset* N-204

Richmond, University of, at Richmond, Va.; Baptist; Richmond College for men (founded as academy 1830, college 1840, present name 1920) and Westhampton College for women (opened 1914) are coordinate colleges; arts and sciences, business administration, law; coeducational in graduate and professional schools.

Richmond Heights, Mo., residential city adjoining St. Louis on the west; pop. 15,045; incorporated in 1913: *map, inset* M-319

Richter (*rĭk'tẽr*), **Conrad** (born 1890), writer, born Pine Grove, Pa.; known for novels of frontier life (trilogy: 'The Trees', The Fields', 'The Town', 1951 Pulitzer prize; 'Light in the Forest').

Richter (*rĭk'tẽr*), **Hans** (1843–1916), Austrian musical conductor, born Hungary; conducted in Vienna, Bayreuth, London, and other cities; closely associated with Richard Wagner and authority on his music.

Richter, Hieronymus Theodor (1824–98), German metallurgist; discoverer, with Ferdinand Reich, of indium.

Richter, Johann Paul Friedrich (1763–1825), pseudonym Jean Paul, German novelist and humorist; quite popular in his own time but now little read because of his rather baffling style ('Quintus Fixlein'; 'Flegeljahre', translated as 'Wild Oats'; 'Titan')
place in German literature G-84

WORLD'S LONGEST RIVERS

Name	Continent	Length in Miles
Amazon	South America	3900
Mississippi-Missouri	North America	3872
Nile	Africa	3473
Congo	Africa	3000
Yangtze	Asia	3000
Yenisei	Asia	3000
Lena	Asia	2860
Amur	Asia	2700
Hwang	Asia	2700
Mackenzie	North America	2635
Mekong	Asia	2600
Niger	Africa	2600
Ob	Asia	2500
Volga	Europe	2325

Roberval (*rô-bêr-väl'*), **Jean François de la Roque, sieur de** (1501?–60?), French Canadian colonizer C-130

Robeson, Paul (born 1898), Negro actor and singer, born Princeton, N. J.; won high scholastic and athletic honors at Rutgers College; graduated Columbia Law School; established reputation as singer of Negro spirituals and as actor in 'The Emperor Jones', 'All God's Chillun's Got Wings', 'The Hairy Ape', 'Show Boat', 'Othello'.

Robespierre (*rôbs-pē-yêr'*), **Maximilien** (1758–94), leader in French Revolution R-163, F-294
 Danton and D-15, R-163
 Madam Roland and R-179

Robidou (*rō-bē-dọ'*) **brothers**, American trappers and fur traders: **Antoine** (1794–1860), "first fur trader out of old Taos," trapped in Nebraska and Utah, built post on Gunnison River in Colorado (1828) and Fort Robidou in n. e. Utah (1832); **Joseph** (1783–1868) traded at Council Bluffs until American Fur Company intervened; began trading at Blacksnake Creek for American Fur Company 1812; by 1830 owned fort around which St. Joseph, Mo., grew up; **François**, **Louis**, and **Michel** are less known.

Robin R-163–4, *pictures* R-164, N-57, A-250*a*, color *picture* B-186
 egg R-164, color *picture* E-268*a*
 food required, *picture* B-156
 hatching period B-174
 nest B-172, R-164, *pictures* B-173, N-57, R-164
 pet, *picture* P-182*b*
 state bird R-164, *table* B-158
 trillium legend T-189
 young, *pictures* N-57: color B-178

Robin Goodfellow, or **Puck**, in Shakespeare's 'Midsummer Night's Dream' M-240

Robin Hood, famous English outlaw R-164–6, *pictures* R-165, L-216
 motion picture, color *picture* M-409

Robin Hood Dell, in Philadelphia, Pa.; natural amphitheater for summer music concerts; founded 1930.

Robinson, Benjamin Lincoln (1864–1935), botanist, born Bloomington, Ill.; curator Gray Herbarium after 1892 and professor systemic botany, Harvard University after 1899; author of many botanical papers.

Robinson, Boardman (1876–1952), American painter, born Canada; illustrator and cartoonist for American and English periodicals; murals in Rockefeller Center, New York City.

Robinson, Charles (1818–94), statesman, first governor of state of Kansas; born Hardwick, Mass., emigrated west; did much to prevent California and Kansas becoming slave states; as governor charged with treason and usurpation of authority but acquitted.

Robinson, Edwin Arlington (1869–1935), American poet R-166, A-230*c*
 quoted A-230*c*

Robinson, Henry Crabb (1775–1867), English journalist and diarist; friend of Lamb, Wordsworth, Coleridge, and Southey ('Dairy'; 'Reminiscences'; 'Correspondence').

Robinson, Irene Bowen (born 1891), artist and illustrator, born South Bend, Wash.; illustrated children's books written by her husband, **William Wilcox Robinson** (born 1891) ('Animals in the Sun'; 'Elephants'; 'On the Farm'; 'Picture Book of Animal Babies').

Robinson, Jack (Roosevelt) (born 1919), Negro all-round athlete, born Cairo, Ga.; joined Brooklyn Dodgers baseball team 1947, the first Negro to play in major leagues in modern times.

Robinson, James Harvey (1863–1936), historian and educator, born Bloomington, Ill. ('An Introduction to the History of Western Europe', 'Medieval and Modern Times', 'The Mind in the Making'; collaborated with James Henry Breasted, Charles Austin Beard, and others on 'History of Civilization')
 quoted on history H-360

Robinson, John (1575?–1625), English nonconformist, pastor of Leyden, Netherlands, congregation of Pilgrim Fathers; organized Speedwell-Mayflower colony, but died at Leyden.

Robinson, Sir John Beverley (1791–1863), Canadian jurist and statesman, chief justice of Upper Canada 1829–63; opposed reforms of Baldwin and Lafontaine and was trusted guide of the "Family Compact."

Robinson, Joseph Taylor (1872–1937), political leader, born Arkansas; U. S. Congressman 1902–12; governor of Arkansas 1912, U. S. senator few weeks later; as Democratic floor leader in Senate showed great parliamentary ability; Democratic nominee for vice-president 1928.

Robinson, Lennox (born 1886), Irish dramatist and novelist, born Douglas, Cork; director Abbey Theatre, Dublin ('Harvest'; 'A Young Man from the South'; 'The White-headed Boy'; 'The White Blackbird').

Robinson, Mabel Louise (born 1884?), author of children's books, born Waltham, Mass.; instructor in juvenile writing at Columbia University ('Bright Island'; 'Runner of the Mountain Tops').

Robinson, Sir Robert (born 1886), English chemist; professor of chemistry, Oxford University since 1930; won 1947 Nobel prize in chemistry for his research on plant products of biological importance.

Robinson, Theodore (1852–96), painter, born Irasburg, Vt.; works are notable for skillful light effects; best known for landscapes and figures outdoors.

Robinson, William (1840–1921), engineer and inventor, born County Tyrone, Ireland; to U.S. as child
 railroad signaling system R-66

'Robinson Crusoe', novel by Daniel Defoe D-46, C-523–4, *pictures* C-523, E-378*a*
 basis in fact C-523–4, *picture* C-251
 relation to novel N-311

Robinson-Patman Price Discrimination Act, amendment to Clayton Act of 1914; enacted 1936 to prevent price discrimination between buyers of same commodity; act protected independent merchants against quantity buying of chain stores
 chain store price regulation C-182

Robot (*rō̆b'ŏt*), term for mechanical man, from Czech word meaning "work"; popularized by Karel Capek's play 'R. U. R.' in which mechanical workers carried on work of world.

Rob Roy (Robert MacGregor or Campbell) (1671–1734), celebrated Scottish outlaw R-166

Rob Roy canoe C-114

Robsart (*rō̆b'särt*), **Amy** (1532–60), wife of Lord Robert Dudley, afterward earl of Leicester, who was suspected of having caused her sudden death in order that he might be free to marry Queen Elizabeth I; story told in Scott's 'Kenilworth'.

Rob'son, Eleanor (Mrs. August Belmont) (born 1879), American actress, born England; first appeared on American stage 1897; starred in 'Merely Mary Ann', 'Salomy Jane', 'The Dawn of a Tomorrow' (her greatest success); retired from stage 1910; afterward active in social and philanthropic work.

Robson, Stuart (1836–1903), comedian, born Annapolis, Md.; his real name was Henry Robson Stuart; greatest success in 'The Henrietta' by Bronson Howard.

Robson, Mount, British Columbia, Canada, one of highest peaks of Canadian Rocky Mountains (12,972 ft.).

Robusti, Jacopo. *See in Index* Tintoretto

Roc (*rŏk*), a monster bird in Arabic legend, said to have its home in Madagascar; so large that it could carry off elephants. Sinbad the Sailor tells of seeing its egg, which was "50 paces in circumference."

Roca (*rō'kä*), **Julio Argentino** (1843–1914), Argentine soldier and statesman; rose to general in war with Paraguay (1865–70); suppressed rebellion 1880, and elected president (1880–90; again 1898–1904); greatly strengthened national administration and patriotic spirit.

Rocas Reef, island in Atlantic Ocean A-451

Rochambeau (*rô-shäṅ-bō*), **Jean Baptiste Donatien de Vimeur, count de** (1725–1807), French soldier R-166

Rochdale (*rŏch'dāl*), England, manufacturing town 10 mi. n.e. of Manchester; pop. 87,734; cottons and woolens; 'Rochdale Pioneers', 1844, first English co-operative society: *map* B-325
 Rochdale principles C-469

Rochdale Society of Equitable Pioneers, in England C-469, E-369*d*

Roche (*rōsh*), **Arthur Somers** (1883–1935), novelist, born Somerville, Mass.; also magazine writer ('Ransom'; 'Uneasy Street'; 'Day of Faith'; 'What I Know about You'; 'The Sport of Kings').

Roche, Mazo de la. *See in Index* De la Roche

Rochefort (*rôsh-fôr'*), (**Victor Henri, marquis de Rochefort-Luçay**) (1830–1913), French journalist and political leader, bitter opponent of Napoleon III, supporter of the Commune, several times exiled and imprisoned for his attacks on persons and projects he believed wrong.

Rochefort, France, fortified naval harbor 75 mi. n. of Bordeaux near mouth of Charente River; pop. 22,-930; nearby Napoleon surrendered to British 1815: *map* E-425

Rochefoucauld, François de la. *See in Index* La Rochefoucauld, François, duc de

Rochelle, La, France. *See in Index* La Rochelle

Rochelle salt, a double salt of tartaric acid (sodium potassium tartrate); produced in the action of cream-of-tartar baking powders T-21
 Seidlitz powders contain S-31

Roch'ester, England, port on Medway River 26 mi. s.e. of London; pop. 43,899; noted cathedral, ruined castle: *map* B-325

Rochester, Minn., industrial city in s.e., 35 mi. n. of Iowa boundary; pop. 29,885; vegetable canning, dairy products, baked goods, electrical and metal equipment, cosmetics; Rochester Junior College: M-278, 280, *maps* M-287, U-253. *See also in Index* Mayo Clinic

Rochester, N. H., city on Cocheco River, 34 mi. n.e. of Manchester, in farming district; pop. 13,776;

GEOLOGICAL CLASSIFICATION OF ROCKS

Igneous Rocks

Note: All rocks in Groups I and II erupted, and so did most of those in Group III. Most rocks in Group IV hardened underground, but gabbro is also found near the center of some thick lava flows. Some felsites, andesites, and basalts hardened underground but close to the earth's surface.

Feldspathic Types (contain much feldspar). Generally light-colored.	Ferromagnesian Types (named for content of iron, magnesium). Generally dark-colored.
I. Glassy Rocks	
Obsidian—Solid glassy lava, light to black in color. Thin chips are translucent.	
Pumice—Very porous glassy lava, in fibers filled with holes.	Pitchstone—Obsidian containing water in microscopic bubbles.
II. Fragmental Rocks	
Tuff (volcanic ash), agglomerate (ash and large fragments), etc.—White to dark brown or black.	
III. Fine-Grained Rocks ("Aphanites")	
Felsite—Chiefly quartz and feldspar. Fine-grained equivalent of granite.	Basalt—Green to black. Feldspar, olivine, magnetite, etc. Contains much lime, which forms crusts on weathered blocks.
Rhyolite—An almost glassy felsite.	Andesite—Gray or pink to dark brown. Commonly porphyritic. Abundant in the West.
IV. Coarse-Grained Rocks ("Phanerites")	
Granite—Quartz, feldspars, generally mica and some other materials.	Gabbro—Dark gray or black. Contains feldspar and dark minerals. Crystals generally small.
Syenite—Much feldspar but little quartz; generally some black mica and other dark minerals.	
Diorite—Feldspar and some iron-bearing minerals. Often called gray granite.	

Sedimentary and Metamorphic Rocks

Unconsolidated Sediment	Consolidated Rock	Metamorphosed Rock	Highly Metamorphosed Rock
Pebbles, large stones	Conglomerate	Gneiss	Schist
Sand	Sandstone	Quartzite	Quartz schist
Mud, silt, clay	Shale	Slate, hornfels	Schist, serpentine
Lime mud, shells, corals, etc.	Limestone	Marble	Marble or talc schist (rare)
Dolomite mud sea plants	Dolomite	Marble	Talc schist (rare)
Dead plants	Soft coal	Anthracite	Graphite

EMPERORS OF ROME

27 B.C.–A.D. 14	Augustus
14–37	Tiberius
37–41	Caligula
41–54	Claudius
54–68	Nero
68–69	Galba
69	Otho
69	Vitellius
69–79	Vespasian
79–81	Titus
81–96	Domitian
96–98	Nerva
98–117	Trajan
117–138	Hadrian
138–161	Antoninus Pius
161–180	Marcus Aurelius
180–192	Commodus
193	Pertinax
193	Didius Julianus
193–211	Septimius Severus
211–217	Caracalla
217	Macrinus
218–222	Heliogabalus
222–235	Alexander Severus
235–238	Maximinus
238	Gordian I, Gordian II } jointly
238	Pupienus, Balbinus } jointly
238–244	Gordian III
244–249	Philip the Arabian
249–251	Decius
251–253	Gallus
253	Aemilian
253–260	Valerian } jointly
253–268	Gallienus } jointly
268–270	Claudius II
270–275	Aurelian
275	Tacitus
276–282	Probus

282–283	Carus
284	Carinus, Numerianus } jointly
284–305	Diocletian } jointly
286–305	Maximianus } jointly
305–306	Constantius Chlorus (West) } jointly
305–311	Galerius (East) } jointly
306–312	Maxentius (West)
306–337	Constantine the Great (West, later all) } jointly
307–323	Licinius (East) } jointly
337–361	Constantius (East, later all) } jointly
337–340	Constantine II (West) } jointly
337–350	Constans (Africa) } jointly
361–363	Julian
363–364	Jovianus
364–375	Valentinian I (West)
364–378	Valens (East)
375–383	Gratian } (West jointly)
375–392	Valentinian II } (West jointly)
379–395	Theodosius I (East, later all)

WESTERN EMPIRE

395–423	Honorius
424	John
425–455	Valentinian III
455	Maximus
455–456	Avitus
457–461	Majorian
461–465	Libius Severus
465–467	Recimir
467–472	Anthemius
472	Olybrius
473	Glycerius
473–475	Julius Nepos
475–476	Romulus Augustulus

RULERS OF RUSSIA BEFORE THE 1917 REVOLUTION

House of Rurik	
1462–1505	Ivan III, the Great
1505–1533	Vassili Ivanovitch
1533–1584	Ivan IV, the Terrible
1584–1598	Feodor Ivanovitch
1598–1605	Boris Gudenov
1605–1613	Time of the troubles
House of Romanov	
1613–1645	Michael
1645–1676	Alexis
1676–1682	Feodor Alexievitch
1682–1689	Ivan V / Peter the Great } jointly
1689–1725	Peter the Great (alone)
1725–1727	Catherine I
1727–1730	Peter II
1730–1740	Anna Ivanovna
1740–1741	Ivan VI
1741–1762	Elizabeth
1762	Peter III
1762–1796	Catherine II
1796–1801	Paul I
1801–1825	Alexander I
1825–1855	Nicholas I
1855–1881	Alexander II
1881–1894	Alexander III
1894–1917	Nicholas II
[1917	Czarist rule overthrown]

Triple Entente (1907) T-177, E-434, E-266
Iran, relations with I-223–4
World War I R-288, *map* W-222 *See also in Index* World War I, chronology
reasons for entering W-216–17
military events W-221, 226
national debt after, *table* N-17
first revolution of 1917 R-288
Nicholas II overthrown N-234
Kerensky heads government R-288
Bolshevist Revolution (1917) R-288–9
leaders Lenin L-162; Trotzky T-192; Stalin S-361
dictatorship D-88, D-66
Treaty of Brest-Litovsk W-226, R-289
civil war and allied intervention R-289, W-240–1
loss of Finland F-72
war with Poland W-241, P-344
famine and economic chaos R-289
New Economic Policy (NEP) R-289–90
Stalin succeeds Lenin S-361, R-289
Church suppressed R-272
five-year plans started R-290, 280
Great Purge of the Communist party R-290–1
influence in China C-282–3: Manchuria M-75–6, Mongolia M-344, 345
intervention in Spain S-322*a*
constitution of 1936 R-281
polar exploration P-350*a*, 351, *map* P-346, *table* P-349
World War II *See also in Index* World War II, chronology
prewar policy W-247, R-291
nonaggression pact with Germany W-247, R-291
Poland partition W-248
war with Finland R-291, W-249
German invasion R-291–2, G-100, W-257–8, 264
United States aid R-213
peace with Japan kept W-259
counterdrive against Germany W-261–2, 264–6, 268, 278
armistice with Finland F-72
war strategy conference W-297
drive into central Europe invasion of Germany W-269, 270–1, 272, *map* W-268
declaration of war against Japan W-272, R-292
national debt after, *table* N-17
territorial gains E-437, R-291, 292, W-298· Bessarabia and Bucovina R-254; Estonia E-400; Finland F-70, Latvia L-135, Lithuania L-276
postwar influence R-292–292*b*
in Europe E-437–9, B-27: Bulgaria B-350; Czechoslovakia C-536; Germany G-100, 101–3; Hungary H-451; Poland P-345, Rumania R-252, 254; Yugoslavia Y-347–8
in Middle East Iran I-223–4, Turkey T-220*b*
in Far East Korea K-65–6; Manchuria M-76, Mongolia M-342
in United Nations U-240–3
peace problems W-297–301, *pictures* W-298–301
fourth and fifth 5-year plans R-280
Stalin's death R-292*a*
occupation of Austria ends E-439

Russia leather L-150

Russian-American Company, Alaska flag F-130*d*, *color picture* F-128

Russian Blue cat C-136*a*, *picture* C-136*a* *See also in Index* Cat, *table*

Russian desman, animal *See in Index* Desman

Russian Hill, San Francisco, Calif S-41–41*a*

Russian language R-294
alphabet A-179, R-294. *See also in Index* Alphabet, *table*
number speaking L-98
personal names N-2*b*

Russian literature R-294–6, *pictures* R-294–5, *Reference-Outline* L-99. *See also in Index* names of chief writers
chief writers *list* R-295–6
dramatists *list* D-137
folk tales R-263, S-409–10, *list* S-420
novel R-294, 295

Russian mile, *table* W-87

Russian mulberry, small bushy tree, a variety of the white mulberry; dark red or white fruit, in w U S sometimes planted as a windbreak.

Russian Orthodox church R-272–3
in old Russia R-263

Russian Quakers, or **Dukhobors**. *See in Index* Dukhobors

Russian River, of w California, rises in Mendocino County, flows s. then w into Pacific Ocean, 107 miles long, resort area famed for fishing: *map* C-34

Russian sable, fur of Siberian sable marten M-104

Russian Social Democratic party C-426

Russian Soviet Federated Socialist Republic (commonly designated as R S F S R), largest of the constituent republics of the Soviet Union, area, more than 6 300,000 sq mi , pop 111,000,000, cap Moscow *map* R-260

Russian thistle, annual plant (*Salsola kali*) of goosefoot family, name from Latin *salsus* ("salty") refers to growth in salty places Classed as a tumbleweed

Russian Turkestan T-213 214

Russian wolfhound, or **borzoi**, *table* D-118*a*

Russo-Japanese War (1904–5) R-296
effect on Russia R-287, P-13
T Roosevelt's mediation R-222

Russo-Turkish wars. *See also in Index* Crimean War
(1828–29) G-191
(1877–78) B-26
Berlin, Congress of B-130, T-220*a*
Bosnia and Herzegovina B-256
Bulgaria B-349

Russwurm John Brown (1799–1851), Negro editor, publisher, and statesman born Port Antonio Jamaica; first Negro college graduate in U S (Bowdoin 1826), published first Negro newspaper (*Freedom's Journal*) his antislavery pleas aroused enmity, emigrated to Liberia (1829) where he became superintendent of public schools and edited *Liberia Herald*, governor of Maryland Colony, Cape Palmas 1836–51

Rust, John Daniel (1892–1954), and his brother **Mack Donald** (born 1900), inventors born Stephens County, Tex , patented cotton-picking machine 1936

Rust, oxidized iron R-296–7
alloys that resist A-172
chemical reaction C-210
metal coatings to prevent cadmium C-10; chromium C-300; zinc (galvanized iron) Z-351
wax used to prevent W-76

Rustam, or **Rustum**, legendary hero of Persia (Iran) S-409

Rustchuk, Bulgaria *See in Index* Ruse

Rust College, at Holly Springs Miss ; Methodist, founded 1866, arts and sciences, education

Rustic capitals, Latin manuscript writing B-232

Rustless iron C-300

Ruston, La , town 62 mi e of Shreveport, pop 10,372, farming, gas wells; airport, Louisiana Polytechnic Institute, Grambling College *map* L-330

Rusts, various fungi parasitic upon plants R-297–9, F-316, *pictures* R-297–8
control R-298–9
white pine blister rust C-530

Rusty blackbird B-203

Rutaba'ga, or **Swedish turnip** C-1
when and how to plant G-19, *table* G-19

Rutgers University, at New Brunswick, Newark, and Camden, N J., chartered 1766, colleges for men in arts and sciences agriculture education, and engineering and Douglass College, for women, are at New Brunswick, arts and sciences business administration law, and pharmacy at Newark and the College of South Jersey at Camden are coeducational Rutgers is state university of New Jersey
first intercollegiate football game F-230–1
honors courses U-403

Ruth, Biblical heroine R-299, *picture* R-299

Ruth, George Herman (Babe) (1895–1948), American baseball player R-299–300, *pictures* R-300, B-65. *See also in Index* Baseball Hall of Fame, *table*

Ruthe'nia, also **Carpatho-Ukraine**, Russia, district in w Ukraine, 4871 sq mi , pop about 900 000, part of Austria-Hungary until incorporated in Czechoslovakia 1918, retaken by Hungary 1939, ceded to Ukrainian S S R 1945 C-536, *map* C-535

Ruthenians, branch of Slavs U-233

Ruthenium, a chemical element found in platinum ores, *tables* P-151, C-214
found with platinum P-315

Rutherford (*rŭth'ẽr-fẽrd*) **Daniel** (1749–1819), British physician and botanist
recognized nitrogen N-241

Rutherford, Ernest Rutherford, first Baron (1871–1937), British physicist born Nelson, New Zealand, professor physics, McGill University, Montreal Canada, 1898–1907; director Cavendish Laboratory, Cambridge University, Cambridge England, 1919–37, Nobel prize for chemistry 1908; author of books and papers on radioactivity· R-53, 54 H-459, *picture* P-236
atomic numbers C-212
transmutation of elements A-462

Rutherford (*rŭth'ẽr-fẽrd*) **N J**, town 9 mi n w of Jersey City, chiefly residential community, pop 17,411. *map, inset* N-164

Rutilated quartz. *See in Index* Sagenite

Rutile (*rū'tīl*), an adamantine, reddish brown, transparent to opaque titanium dioxide ore P-40, M-262

Rutin, a drug derived from buckwheat and some other plants, used in reducing high blood pressure

Rutland, Vt , 2d city of state, near center, on Otter Creek in dairying and marble-quarrying section pop 17 659 V-460, *maps* V-457, U-253

Rutland, or **Rutlandshire**, one of smallest English counties, between Leicestershire Northamptonshire, and Lincolnshire, 152 sq mi , pop 20,510 · *map* E-347

Rutledge, Ann (1816?–35), daughter of Abraham Lincoln's landlord an innkeeper of New Salem, Ill her sudden death saddened Lincoln

Rutledge, Archibald Hamilton (born 1883), writer and naturalist, born McClellanville S C contributor to magazines ('Plantation Game Trails', 'Wild Life of the South', 'Plantation Saga').

Rutledge, Edward (1749–1800), statesman, born Charleston S C ; brother